



C E R T I F I C A T I O N

I, Takashi KOJIMA of Ginza Ohtsuka Bldg., 2F, 16-12, Ginza 2-chome, Chuo-ku, Tokyo, Japan, hereby certify that I am the translator of the accompanying certified official copy of the documents in respect of an application for a patent filed in Japan on the 21st of May, 2003 and of the official certificate attached thereto, and certify that the following is a true and correct translation to the best of my knowledge and belief.

Dated this 2nd day of May, 2006


Takashi KOJIMA

(Translation)

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Applicant(s): Shin-Etsu Chemical Co., Ltd.

March 5, 2004

Commissioner,
Japan Patent Office Yasuo IMAI
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2003-142853

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[Official Fee]

[Deposit Account Number] 003207
[Amount of Fee] 21000

[List of Documents Attached]

[Document]	Specification	1
[Document]	Abstract	1

[Necessity of Proof] Yes

2003-142853

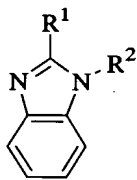
[SPECIFICATION]

[TITLE OF THE INVENTION] Basic Compound, Resist Composition
and Patterning Process

5 [CLAIMS]

[Claim 1] A resist composition comprising one or more
basic compounds having a benzimidazole skeleton and a polar
functional group, represented by the general formula (1):

[Formula 1]



(1)

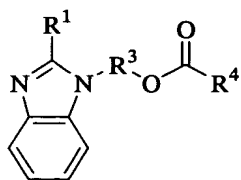
10

wherein R¹ is a hydrogen atom, a straight, branched or cyclic
alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to
10 carbon atoms, or an aralkyl group of 7 to 10 carbon
atoms; and R² is a polar functional group-bearing straight,
15 branched or cyclic alkyl group of 1 to 20 carbon atoms
wherein said alkyl group contains as the polar functional
group at least one group selected from among ester, acetal
and cyano groups, and optionally at least one group selected
from among hydroxyl, carbonyl, ether, sulfide and carbonate
20 groups.

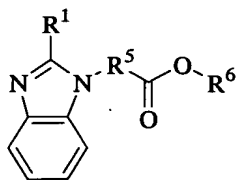
20

[Claim 2] A resist composition comprising one or more
basic compounds having a benzimidazole skeleton and a polar
functional group, represented by the general formulae (2) to
(7):

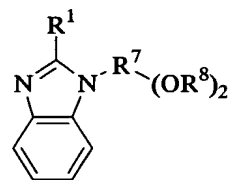
[Formula 2]



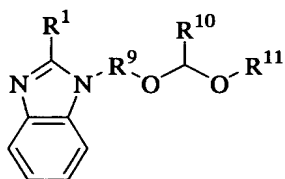
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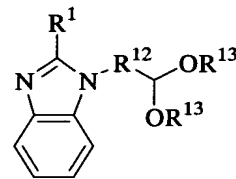
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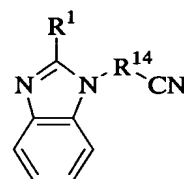
(4)



(5)



(6)



(7)

wherein R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms;

R³, R⁵, R⁹, R¹² and R¹⁴ are each independently a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms;

R⁴ is a hydrogen atom or an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups;

R⁶ is an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups;

R⁷ is a trivalent, straight, branched or cyclic hydrocarbon group of 2 to 10 carbon atoms;

R⁸ is each independently an acyl group of 1 to 10 carbon atoms which may contain at least one ester or ether group, or two R⁸ may bond together to form a cyclic carbonate or cyclic acetal;

R¹⁰ is a hydrogen atom or a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms;

R¹¹ is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms which may contain at least one group selected from among ether, sulfide and acetal groups, or R¹⁰ and R¹¹ may bond together to form a ring;

5 R¹³ is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, or two R¹³ may bond together to form a ring.

[Claim 3] A positive-working resist composition comprising:

- (A) the basic compound of claim 1 or 2;
- 10 (B) an organic solvent;
- (C) a base resin having an acid labile group-protected acidic functional group which is alkali-insoluble or substantially alkali-insoluble, but becomes alkali-soluble when the acid labile group is eliminated; and
- 15 (D) a photoacid generator.

[Claim 4] The positive resist composition of claim 3 which further comprises (E) a dissolution inhibitor.

[Claim 5] A negative-working resist composition comprising:

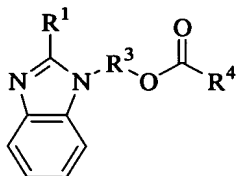
- (A) the basic compound of claim 1 or 2;
- 20 (B) an organic solvent;
- (C') a base resin which is alkali-soluble, but becomes substantially alkali-insoluble when crosslinked with a crosslinking agent;
- (D) a photoacid generator; and
- 25 (F) a crosslinking agent which induces crosslinkage under the action of an acid.

[Claim 6] A patterning process comprising the steps of:

- (1) applying the positive resist composition of any one of claims 3 to 5 onto a substrate;
- 30 (2) heat treating the applied resist, then exposing the heat-treated resist through a photomask to high-energy radiation having a wavelength of at most 300 nm or an electron beam; and
- (3) heat treating the exposed resist, then developing
- 35 the resist with a liquid developer.

[Claim 7] A basic compound represented by the general formula (2):

[Formula 3]



(2)

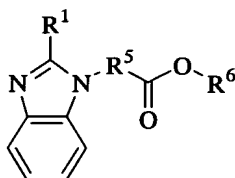
5 wherein R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms;

10 R³ is a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms; and

R⁴ is a hydrogen atom or an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups.

15 [Claim 8] A basic compound represented by the general formula (3):

[Formula 4]



(3)

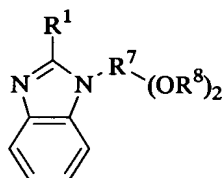
20 wherein R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms;

R⁵ is a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms; and

25 R⁶ is an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups.

[Claim 9] A basic compound represented by the general formula (4):

[Formula 5]



(4)

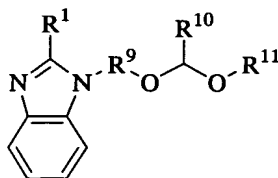
5 wherein R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms;

R⁷ is a trivalent, straight, branched or cyclic
10 hydrocarbon group of 2 to 10 carbon atoms; and

R⁸ is each independently an acyl group of 1 to 10 carbon atoms which may contain at least one ester or ether group, or two R⁸ may bond together to form a cyclic carbonate or cyclic acetal.

15 [Claim 10] A basic compound represented by the general formula (5):

[Formula 6]



(5)

20 wherein R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms;

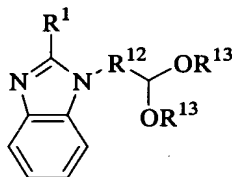
R⁹ is a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms;

25 R¹⁰ is a hydrogen atom or a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms;

R^{11} is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms which may contain at least one group selected from among ether, sulfide and acetal groups, or R^{10} and R^{11} may bond together to form a ring.

5 [Claim 11] A basic compound represented by the general formula (6):

[Formula 7]



(6)

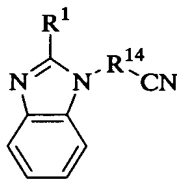
10 wherein R^1 is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms;

R^{12} is a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms; and

15 R^{13} is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, or two R^{13} may bond together to form a ring.

[Claim 12] A basic compound represented by the general formula (7):

20 [Formula 8]



(7)

25 wherein R^1 is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms; and

R^{14} is a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms.

[DETAILED EXPLANATION OF THE INVENTION]

[0001]

[Technical Field of the Invention]

The present invention relates to a novel resist
5 composition suitable for microfabrication technology, and
more particularly to a chemical amplification resist
composition, and to a patterning process using the resist
composition.

[0002]

10 [Prior Art]

Of the efforts currently being made to achieve a finer
pattern rule in the drive for higher integration and
operating speeds in LSI devices, deep-ultraviolet
lithography is thought to hold particular promise as the
15 next generation in microfabrication technology. Deep-UV
lithography is capable of fabrication to dimensions of 0.2 μm
or less and, when a resist having low light absorption is
used, can form patterns with sidewalls that are nearly
perpendicular to the substrate. One technology that has
20 attracted a good deal of attention recently utilizes
high-intensity KrF and ArF excimer lasers as the deep-UV
light source. This technology is being used in large-volume
production, prompting a desire for resists having a low
light absorption and a high sensitivity.

25 [0003]

Acid-catalyzed, positive-working chemical
amplification resists (e.g., Patent Documents 1 and 2: JP-B
2-27660 and JP-A 63-27829) developed in response to the
above needs are endowed with excellent properties, including
30 a high sensitivity, high resolution and good dry-etching
resistance, which make them especially promising as resists
for deep-UV lithography.

[0004]

However, one problem with chemical amplification
35 resists is that, when the standing time from exposure to
post exposure bake (PEB) is long, the line pattern formed
during patterning acquires a "T-top" shape characterized by

widening at the top of the pattern. This defect is called "post exposure delay" (PED). Another problem with such resists is "footing," which is a widening of the resist pattern close to the substrate that occurs on a basic substrate, particularly a silicon nitride or titanium nitride substrate. The T-top effect is believed to result from a decrease in solubility at the surface of the resist film, and the footing effect at the substrate surface appears to arise from a decline in solubility near the substrate. An additional problem is that acid-labile group elimination is a dark reaction which proceeds during the interval between the exposure step and the PEB step, reducing the final dimensions of the pattern lines. These problems represent major drawbacks to the practical use of chemical amplification resists. Because of such defects, prior-art positive-working chemical amplification resists are difficult to dimensionally control in the lithographic process, and dimensional control is also lost during dry etching of the substrate (see, for example, Non-Patent Documents 1 and 2: W. Hinsberg et. al., Journal of Photopolymer Science and Technology, Vol. 6, No. 4, pp. 535-546 (1993); and T. Kumada et. al., ibid., pp. 571-574).

[0005]

In positive-working chemical amplification resists, the problems of PED and footing on the substrate surface are believed to be caused in large part by basic compounds which are either airborne or present on the surface of the substrate. The acid at the surface of the resist film that has been generated by exposure reacts with airborne bases and is deactivated. Prolonged standing until post-exposure bake results in a corresponding increase in the amount of deactivated acid, making it more difficult for the acid-labile groups to decompose. A substantially insolubilized layer thus forms at the surface, giving the resist pattern a T-top shape.

[0006]

It is well-known in the art that the addition of a basic compound can check the influence of airborne bases, and is thus effective also against PED (see, for example, Patent Documents 3 to 22: JP-A 5-232706, JP-A 5-249683, JP-A 5-158239, JP-A 5-249662, JP-A 5-257282, JP-A 5-289322, JP-A 5-289340, JP-A 6-194834, JP-A 6-242605, JP-A 6-242606, JP-A 6-263716, JP-A 6-263717, JP-A 6-266100, JP-A 6-266111, JP-A 7-128859, JP-A 7-92678, JP-A 7-92680, JP-A 7-92681, JP-A 7-120929 and JP-A 7-134419).

[0007]

Familiar basic compounds include nitrogenous compounds such as amine compounds and amide compounds.

[0008]

Specific examples include pyridine, polyvinylpyridine, aniline, N-methylaniline, N,N-dimethylaniline, o-toluidine, m-toluidine, p-toluidine, 2,4-lutidine, quinoline, isoquinoline, formamide, N-methylformamide, N,N-dimethylformamide, acetamide, N-methylacetamide, N,N-dimethylacetamide, 2-pyrrolidone, N-methylpyrrolidone, imidazole, α -picoline, β -picoline, γ -picoline, o-aminobenzoic acid, m-aminobenzoic acid, p-aminobenzoic acid, 1,2-phenylenediamine, 1,3-phenylenediamine, 1,4-phenylenediamine, 2-quinolinecarboxylic acid, 2-amino-4-nitrophenol, and triazine compounds such as 2-(p-chlorophenyl)-4,6-trichloromethyl-S-triazine.

[0009]

Of these, pyrrolidone, N-methylpyrrolidone, o-aminobenzoic acid, m-aminobenzoic acid, p-aminobenzoic acid and 1,2-phenylenediamine are preferred.

These nitrogenous compounds are weak bases and can alleviate the T-top problem, but such compounds are unable to control the reaction when highly reactive acid-labile groups are used; that is, they cannot control acid diffusion.

With the addition of a weak base, the dark reactions in PED in particular proceed in unexposed areas, causing slimming of the line dimensions and a loss of film thickness from the line surface during PED.

5 To overcome such problems, it is desirable to add a strong base.

[0010]

However, a higher basicity is not necessarily better. For example, good effects cannot be obtained with the

10 addition of the following super-strong bases:

DBU (1,8-diazabicyclo[5.4.0]-7-undecene),

DBN (1,5-diazabicyclo[4.3.0]-5-nonene),

1,8-bis(dimethylamino)naphthalene or quaternary ammonium hydroxides such as

15 tetramethylammonium hydroxide.

The addition of a base having an excellent generated acid capturing effect works well to increase the contrast and thereby achieve a high resolution.

The dissociation constants of the acid and base within 20 water can be explained in terms of pKa, but the acid capturing ability within the resist film is not directly related to the pKa of the base.

This is discussed by Hatakeyama et. al. in Journal of Photopolymer Science and Technology, Vol. 13, No. 4, pp.

25 519-524 (2000) (Non-Patent Document 3).

[0011]

[Patent Document 1]

JP-B 2-27660

[Patent Document 2]

30 JP-A 63-27829

[Patent Document 3]

JP-A 5-232706

[Patent Document 4]

JP-A 5-249683

35 [Patent Document 5]

JP-A 5-158239

[Patent Document 6]

JP-A 5-249662

[Patent Document 7]

JP-A 5-257282

5 [Patent Document 8]

JP-A 5-289322

[Patent Document 9]

JP-A 5-289340

[Patent Document 10]

10 JP-A 6-194834

[Patent Document 11]

JP-A 6-242605

[Patent Document 12]

JP-A 6-242606

15 [Patent Document 13]

JP-A 6-263716

[Patent Document 14]

JP-A 6-263717

[Patent Document 15]

20 JP-A 6-266100

[Patent Document 16]

JP-A 6-266111

[Patent Document 17]

JP-A 7-128859

25 [Patent Document 18]

JP-A 7-92678

[Patent Document 19]

JP-A 7-92680

[Patent Document 20]

30 JP-A 7-92681

[Patent Document 21]

JP-A 7-120929

[Patent Document 22]

JP-A 7-134419

[Non-Patent Document 1]

W. Hinsberg et. al., Journal of Photopolymer
Science and Technology, Vol. 6, No. 4, pp.
535-546 (1993).

5 [Non-Patent Document 2]

T. Kumada et. al., Journal of Photopolymer
Science and Technology, Vol. 6, No. 4, pp.
571-574 (1993).

[Non-Patent Document 3]

10 Journal of Photopolymer Science and Technology,
Vol. 13, No. 4, pp. 519-524 (2000).

[0012]

[Problem to be Solved by the Invention]

The present invention has been done in view of the
15 above circumstances. It is an object of the invention to
provide a resist composition which has a high resist film
thickness loss preventing effect, and also has a high
resolution and a good focus margin widening effect, and to
provide a patterning method which uses the resist
20 composition. A further object of the invention is to
provide a novel basic compound suited for use in the resist
composition.

[0013]

25 [Means for Solving the Problem and Embodiment of the
Invention]

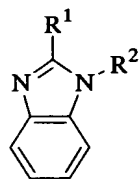
The present inventors have earnestly studied in order
to attain the above objects. As a result, it has been found
that basic compounds of general formula (1), especially
general formulae (2) to (7) below which bear polar
30 functional groups such as ester, cyano or acetal and have a
benzimidazole skeleton can be prepared easily and in a high
yield by the methods described later. When added in an
appropriate amount to a resist, these compounds are highly
effective for preventing a loss of resist film thickness and
35 endow the resist composition with a high resolution and a
focus margin widening effect.

[0014]

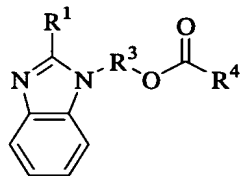
The present invention provides resist compositions, patterning processes, and basic compounds, defined below.

[I] A resist composition comprising one or more basic compounds represented by the general formulae (1) to (7).

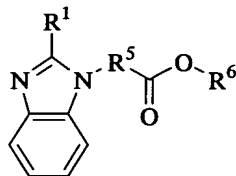
[Formula 9]



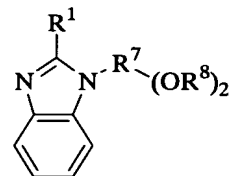
(1)



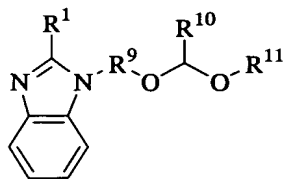
(2)



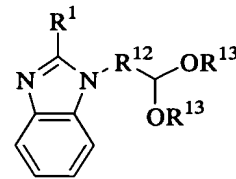
(3)



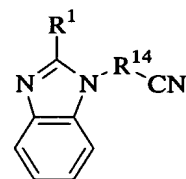
(4)



(5)



(6)



(7)

Herein R^1 is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms; R^2 is a polar functional group-bearing straight, branched or cyclic alkyl group of 1 to 20 carbon atoms wherein said alkyl group contains as the polar functional group at least one group selected from among ester, acetal and cyano groups, and optionally at least one group selected from among hydroxyl, carbonyl, ether, sulfide and carbonate groups; R^3 , R^5 , R^9 , R^{12} and R^{14} are each independently a straight, branched or cyclic alkylene group of 1 to 10

carbon atoms; R^4 is a hydrogen atom or an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups; R^6 is an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups; R^7 is a trivalent, straight, branched or cyclic hydrocarbon group of 2 to 10 carbon atoms; R^8 is each independently an acyl group of 1 to 10 carbon atoms which may contain at least one ester or ether group, or two R^8 may bond together to form a cyclic carbonate or cyclic acetal; R^{10} is a hydrogen atom or a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms; R^{11} is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms which may contain at least one group selected from among ether, sulfide and acetal groups, or R^{10} and R^{11} may bond together to form a ring; and R^{13} is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, or two R^{13} may bond together to form a ring.

[II] A positive-working resist composition comprising:

(A) the basic compound of [I];

(B) an organic solvent;

(C) a base resin having an acid labile group-protected acidic functional group which is alkali-insoluble or substantially alkali-insoluble, but becomes alkali-soluble when the acid labile group is eliminated; and

(D) a photoacid generator.

[III] The positive-working resist composition further comprising:

(E) a dissolution inhibitor in addition to the components of [II].

[IV] A negative-working resist composition comprising:

(A) the basic compound of [I];

(B) an organic solvent;

(C') a base resin which is alkali-soluble, but becomes substantially alkali-insoluble when crosslinked with a crosslinking agent;

(D) a photoacid generator; and

(F) a crosslinking agent which induces crosslinkage under the action of an acid.

[V] A patterning process comprising the steps of:

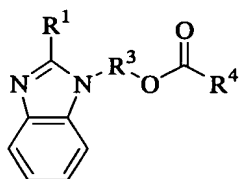
5 (1) applying the resist composition of any one of [II] to [IV] onto a substrate;

(2) heat treating the applied resist, then exposing the heat-treated resist through a photomask to high-energy radiation having a wavelength of at most 300 nm or an
10 electron beam; and

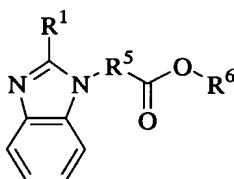
(3) heat treating the exposed resist, then developing the resist with a liquid developer.

[VI] Basic compounds represented by the general formulae (2) to (7)..

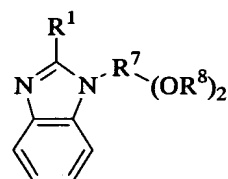
15 [Formula 10]



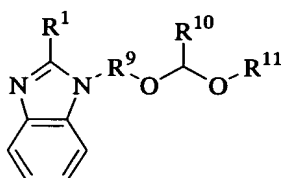
(2)



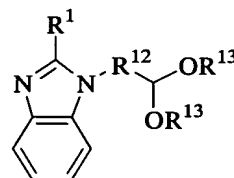
(3)



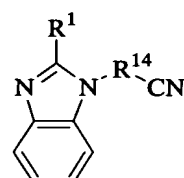
(4)



(5)



(6)



(7)

Herein R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon
20 atoms; R³, R⁵, R⁹, R¹² and R¹⁴ are each independently a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms; R⁴ is a hydrogen atom or an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether,

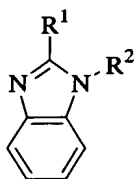
sulfide, carbonate, cyano and acetal groups; R⁶ is an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups; R⁷ is a
5 trivalent, straight, branched or cyclic hydrocarbon group of 2 to 10 carbon atoms; R⁸ is each independently an acyl group of 1 to 10 carbon atoms which may contain at least one ester or ether group, or two R⁸ may bond together to form a cyclic carbonate or cyclic acetal; R¹⁰ is a hydrogen atom or a
10 straight, branched or cyclic alkyl group of 1 to 10 carbon atoms; R¹¹ is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms which may contain at least one group selected from among ether, sulfide and acetal groups, or R¹⁰ and R¹¹ may bond together to form a ring; and R¹³ is a
15 straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, or two R¹³ may bond together to form a ring.

[0015]

The following is the detailed description of the invention.

20 The resist composition of the invention comprises one or more basic compounds having a benzimidazole skeleton and a polar functional group, represented by the general formula (1), preferably basic compounds having a benzimidazole skeleton and a polar functional group, represented by the
25 general formulae (2) to (7) below. It is noted that basic compounds of formulae (2) to (7) are novel.

[Formula 11]

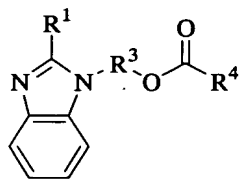


(1)

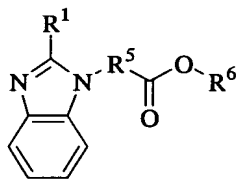
Herein, R¹ is a hydrogen atom, a straight, branched or cyclic
30 alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon

atoms. R^2 is a polar functional group-bearing, straight, branched or cyclic alkyl group of 1 to 20 carbon atoms, and the alkyl group contains as the polar functional group at least one group selected from among ester, acetal and cyano groups, and may additionally contain at least one group selected from among hydroxyl, carbonyl, ether, sulfide and carbonate groups.

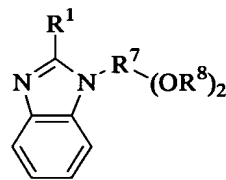
[Formula 12]



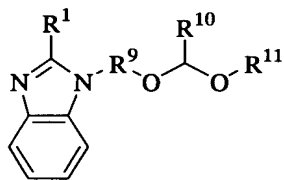
(2)



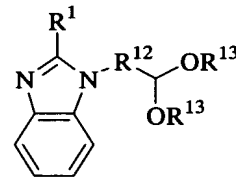
(3)



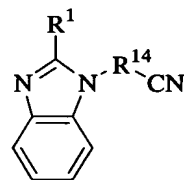
(4)



(5)



(6)



(7)

Herein R^1 is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms; R^3 , R^5 , R^9 , R^{12} and R^{14} are each independently a straight, branched or cyclic alkylene group of 1 to 10 carbon atoms; R^4 is a hydrogen atom or an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups; R^6 is an alkyl group of 1 to 15 carbon atoms which may contain at least one group selected from among hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups; R^7 is a trivalent, straight, branched or cyclic hydrocarbon group of 2 to 10 carbon atoms; R^8 is each independently an acyl group

of 1 to 10 carbon atoms which may contain at least one ester or ether group, or two R^8 may bond together to form a cyclic carbonate or cyclic acetal; R^{10} is a hydrogen atom or a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms; R^{11} is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms which may contain at least one group selected from among ether, sulfide and acetal groups, or R^{10} and R^{11} may bond together to form a ring; R^{13} is a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, or two R^{13} may bond together to form a ring.

[0016]

In formulae (1) to (7), R^1 is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms. Examples of suitable alkyl, aryl and aralkyl groups include, but are not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl, hexyl, decyl, cyclopentyl, cyclohexyl, phenyl, tolyl, xylyl, naphthyl, benzyl and phenethyl.

[0017]

In formula (1), R^2 is a polar functional group-bearing, straight, branched or cyclic alkyl group of 1 to 20 carbon atoms. The alkyl group contains as the polar functional group at least one group selected from among ester, acetal and cyano groups, and may additionally contain at least one group selected from among hydroxyl, carbonyl, ether, sulfide and carbonate groups. Illustrative, non-limiting examples include 2-oxotetrahydrofuran-3-yl, 5-oxotetrahydrofuran-3-yl, 2-oxotetrahydro-2H-pyran-3-yl, 3,3-dicyanopropyl, and 3,3-bis(methoxycarbonyl)propyl groups as well as groups having some of R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , R^{10} , R^{11} , R^{12} , R^{13} and R^{14} such as $-R^3-OCO-R^4$, $-R^5-CO_2-R^6$, $-R^7-(OR^8)_2$, $-R^9-OCH(R^{10})-OR^{11}$, $-R^{12}-CH-(OR^{13})_2$ and $-R^{14}-CN$.

[0018]

In formulae (2), (3), (5), (6) and (7), R^3 , R^5 , R^9 , R^{12} and R^{14} represent straight, branched or cyclic alkylene groups of 1 to 10 carbon atoms, examples of which include,

but are not limited to, methylene, ethylene, ethylidene, propylene, propylidene, isopropylidene, 1,3-propanediyl, 1,4-butanediyl, 1,2-butanediyl, 1,5-pentanediy1, 1,2-pentanediy1, 1,10-decanediyl, 1,2-cyclopentanediy1, 5 1,2-cyclohexanediy1, and 1,4-cyclohexanediy1.

[0019]

In formulae (2) and (3), R⁴ and R⁶ represent straight, branched or cyclic alkyl groups of 1 to 15 carbon atoms which may contain at least one group selected from among 10 hydroxyl, carbonyl, ester, ether, sulfide, carbonate, cyano and acetal groups. Specific, non-limiting examples of suitable alkyl groups include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl, hexyl, decyl, pentadecyl, cyclopentyl, cyclohexyl, 2-tetrahydrofuryl, 15 2-oxo-3-tetrahydrofuryl, 2-tetrahydro-2H-pyranyl, tetrahydrofurfuryl, methoxymethyl, ethoxymethyl, propoxymethyl, (2-methoxyethoxy)methyl, cyanomethyl, methylthiomethyl, acetoxymethyl, formyloxymethyl, 1,3-dioxolan-4-ylmethyl, 20 (2,2-dimethyl-1,3-dioxolan-4-yl)methyl, (2-oxo-1,3-dioxolan-4-yl)methyl, methoxycarbonyl, ethoxycarbonyl, t-butoxycarbonyl, 2-hydroxyethyl, 1-methoxyethyl, 2-methoxyethyl, 1-ethoxyethyl, 2-ethoxyethyl, 2-propoxyethyl, 2-(2-methoxyethoxy)ethyl, 25 2-(2-tetrahydro-2H-pyranyloxy)ethyl, 2-formyloxyethyl, 2-acetoxyethyl, 2-propionyloxyethyl, 2-butyryloxyethyl, 2-valeryloxyethyl, 2-hexanoyloxyethyl, 2-cyanoethyl, 2-methylthioethyl, 2-methoxycarbonyloxyethyl, 2,2-dimethoxyethyl, 2,2-diethoxyethyl, 3,3-dimethoxypropyl, 30 3,3-diethoxypropyl, 2-hydroxypropyl, 2-methoxypropyl, 2-acetoxypropyl, 2-propionyloxypropyl, 3-hydroxypropyl, and 4-hydroxybutyl.

[0020]

In formula (4), R⁷ is a trivalent, straight, branched 35 or cyclic hydrocarbon group of 2 to 10 carbon atoms, examples of which include 1,2,3-propanetriyl, 1,2,3-butanetriyl, 1,2,4-butanetriyl, 1,2,3-pentanetriyl,

2-methylpropane-1,1',3-triyl,
2,2-dimethylpropane-1,1',3-triyl, cyclohexane-1,2,3-triyl,
and cyclohexane-1,3,5-triyl, but are not limited thereto.

[0021]

5 In formula (4), R^8 which may be the same or different
is an acyl group of 1 to 10 carbon atoms which may contain
one or more ester or ether groups. Alternatively, two R^8 may
bond together to form a cyclic carbonate or cyclic acetal.
Illustrative, non-limiting examples of the acyl groups
10 represented by R^8 include formyl, acetyl, propionyl, butyryl,
isobutyryl, valeryl, hexanoyl, octanoyl, decanoyl, pivaloyl,
hexanecarbonyl, methoxyacetyl, (2-methoxyethoxy)acetyl,
[2-(2-methoxyethoxy)ethoxy]acetyl, acetoxycetyl,
2-tetrahydrofuran carbonyl, methoxycarbonyl, and
15 t-butoxycarbonyl. In the event two R^8 bond together to form
a cyclic carbonate or cyclic acetal, R^8 is a carbonyl group
or an alkylidene group. Examples of alkylidene groups
include, but are not limited to, methylene, ethylidene,
propylidene and isopropylidene.

20 [0022]

 In formula (5), R^{10} is a hydrogen atom or a straight,
branched or cyclic alkyl group of 1 to 10 carbon atoms.
Examples of such alkyl groups include, but are not limited
to, methyl, ethyl, propyl, isopropyl, cyclohexyl, and decyl.
25 R^{11} is a straight, branched or cyclic alkyl group of 1 to 10
carbon atoms which may contain at least one group selected
from among ether, sulfide and acetal groups. Examples
include, but are not limited to, methyl, ethyl, propyl,
isopropyl, butyl, isobutyl, pentyl, hexyl, decyl,
30 cyclopentyl, cyclohexyl, methoxymethyl, 2-methoxyethyl, and
methylthiomethyl. When R^{10} and R^{11} bond together to form a
ring, examples of the ring include tetrahydrofuran and
tetrahydro-2H-pyran, but are not limited thereto.

[0023]

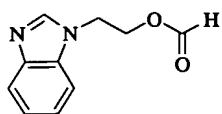
35 In formula (6), R^{13} is a straight, branched or cyclic
alkyl group of 1 to 10 carbon atoms, examples of which
include methyl, ethyl, propyl, isopropyl, butyl, isobutyl,

pentyl, hexyl and decyl. When two R¹³ bond together to form a ring, examples of the ring include 1,3-dioxolane and 1,3-dioxane, but are not limited thereto.

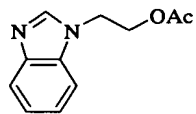
[0024]

5 Specific examples of the basic compounds having a benzimidazole skeleton and a polar functional group according to the invention include, but are not limited to, the following. In the structural formulas that appear below, "Me" represents methyl, "Et" represents ethyl, "t-Bu" 10 represents t-butyl, "Ac" represents acetyl and "Ph" represents phenyl.

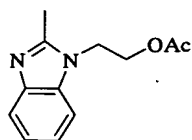
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[Formula 13]



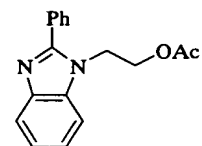
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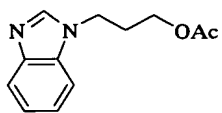
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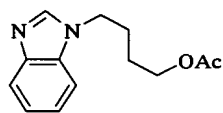
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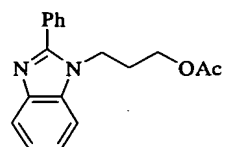
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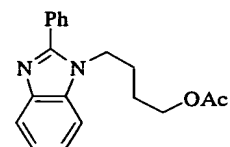
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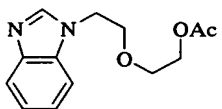
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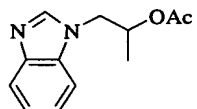
amine 7



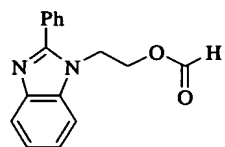
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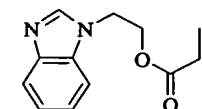
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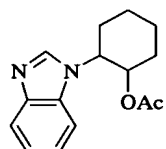
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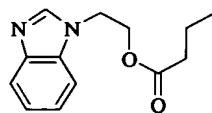
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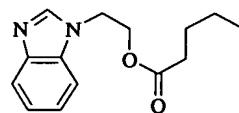
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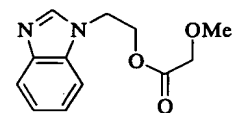
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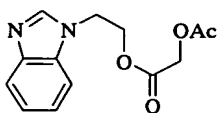
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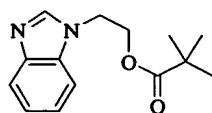
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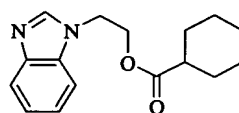
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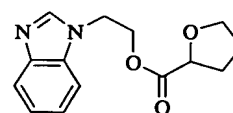
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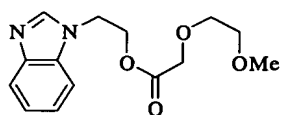
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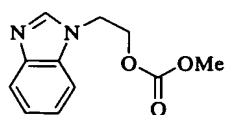
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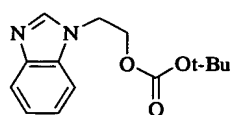
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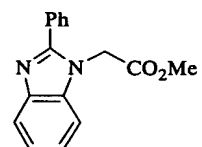
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amine 22

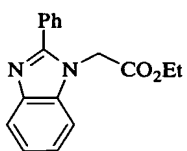


amine 23

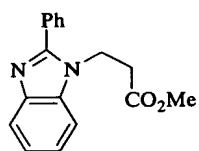


amine 24

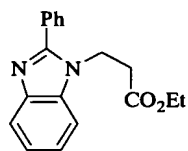
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[Formula 14]



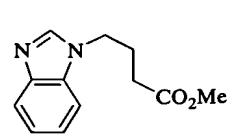
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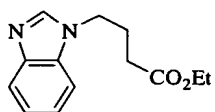
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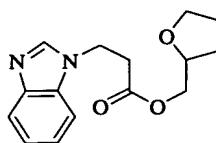
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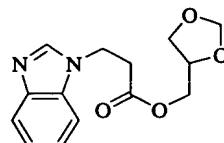
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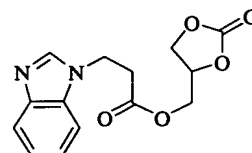
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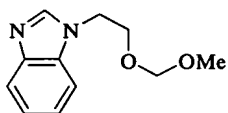
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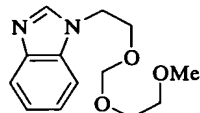
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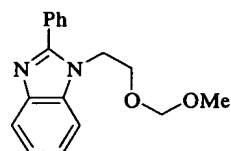
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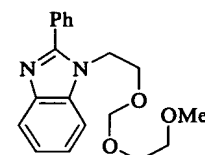
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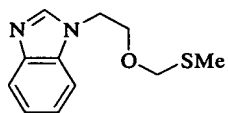
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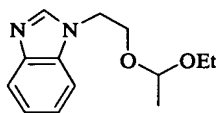
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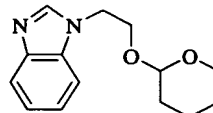
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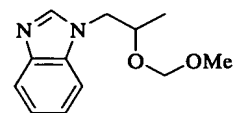
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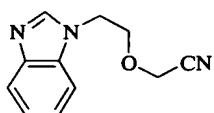
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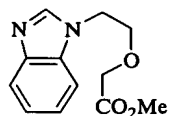
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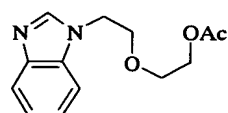
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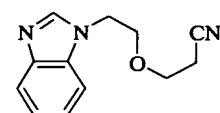
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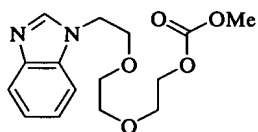
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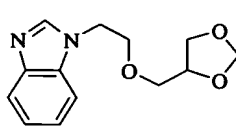
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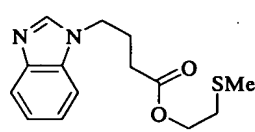
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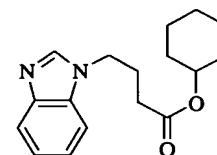
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amine 46

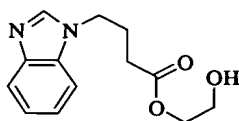


amine 47

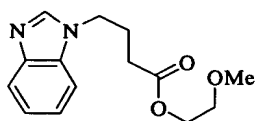


amine 48

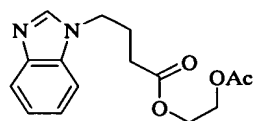
[0027]
[Formula 15]



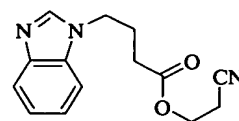
amine 49



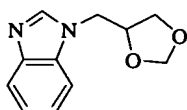
amine 50



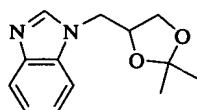
amine 51



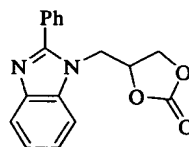
amine 52



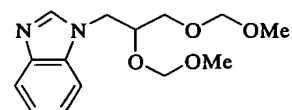
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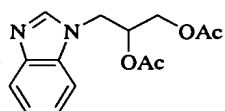
amine 54



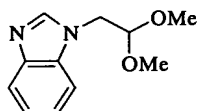
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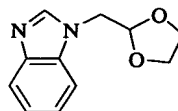
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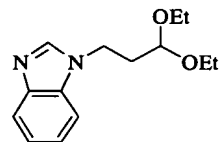
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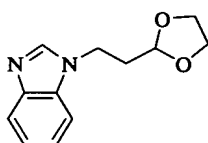
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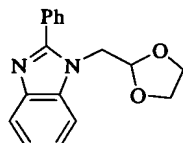
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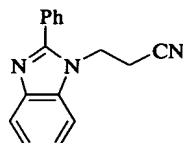
amine 60



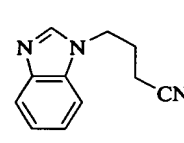
amine 61



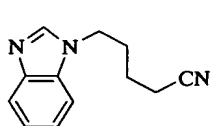
amine 62



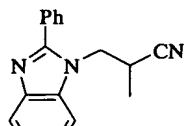
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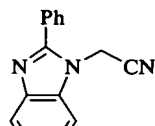
amine 64



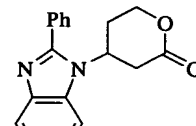
amine 65



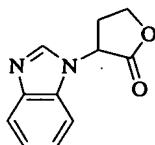
amine 66



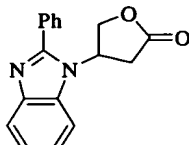
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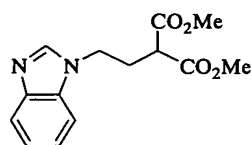
amine 68



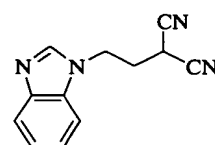
amine 69



amine 70



amine 71



amine 72

[0028]

According to the invention, the basic compounds have a benzimidazole skeleton and a polar functional group moiety within the molecule. The polar functional group having a high kinetic affinity to acids (such as ester, acetal or cyano) can be placed at a suitable position near the amine nitrogen in benzimidazole that ultimately captures the acid. As a result, generated acids can be rapidly captured, enabling photoresists containing these basic compounds to achieve a high resolution and a wide focus margin. By selecting an optimal combination from among the possible combinations of R^1 and R^2 in formula (1), the basicity, acid capturing rate and diffusion rate within the resist can be suitably adjusted. Therefore, the basic compound additives are compatible with a broad range of resist polymers and photoacid generators.

[0029]

The inventive resist composition is most preferably either a positive-working chemical amplification resist composition which includes:

- (A) the above-described basic compound,
- (B) an organic solvent,
- (C) a base resin having an acid labile group-protected acidic functional group, which is alkali-insoluble or substantially alkali-insoluble, but becomes alkali-soluble when the acid labile group is eliminated,
- (D) a photoacid generator and optionally,
- (E) a dissolution inhibitor;

or a negative-working chemical amplification resist composition which includes:

- (A) the above-described basic compound,
- (B) an organic solvent,
- (C') a base resin which is alkali-soluble, but becomes substantially alkali-insoluble when crosslinked with a crosslinking agent (F),
- (D) a photoacid generator, and

(F) a crosslinking agent which induces crosslinkage under the action of an acid.

[0030]

The organic solvent (B) used herein may be any organic
5 solvent in which the base resin, photoacid generator, and
other components are soluble. Illustrative, non-limiting,
examples of the organic solvent include ketones such as
cyclohexanone and methyl-2-n-amylketone; alcohols such as
3-methoxybutanol, 3-methyl-3-methoxybutanol,
10 1-methoxy-2-propanol, and 1-ethoxy-2-propanol; ethers such
as propylene glycol monomethyl ether, ethylene glycol
monomethyl ether, propylene glycol monoethyl ether, ethylene
glycol monoethyl ether, propylene glycol dimethyl ether, and
diethylene glycol dimethyl ether; esters such as propylene
15 glycol monomethyl ether acetate, propylene glycol monoethyl
ether acetate, ethyl lactate, ethyl pyruvate, butyl acetate,
methyl 3-methoxypropionate, ethyl 3-ethoxypropionate,
tert-butyl acetate, tert-butyl propionate, and propylene
glycol mono-tert-butyl ether acetate; and lactones such as
20 γ -butyrolactone. These solvents may be used alone or in
combinations of two or more thereof.

[0031]

Of the above organic solvents, it is recommended to
use diethylene glycol dimethyl ether, 1-ethoxy-2-propanol,
25 propylene glycol monomethyl ether acetate, cyclohexanone and
mixtures thereof because the photoacid generator is most
soluble therein.

An appropriate amount of the organic solvent used is
about 200 to 3,000 parts, especially about 400 to 2,000
30 parts by weight per 100 parts by weight of the base resin.

[0032]

The base polymers used as component (C) or (C') in the
inventive compositions include polyhydroxystyrene (PHS), and
copolymers of PHS with styrene, (meth)acrylic acid esters or
35 other polymerizable olefinic compounds, for KrF excimer
laser resist use; (meth)acrylic acid ester polymers,
alternating copolymers of cycloolefin with maleic anhydride,

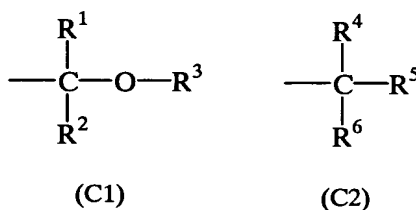
copolymers containing vinyl ethers or (meth)acrylic acid esters, polynorbornene, and ring-opening metathesis polymerized cycloolefins, for ArF excimer laser resist use; and fluorinated forms of the foregoing polymers (for both
 5 KrF and ArF laser uses) for F₂ excimer laser resist use, although the base polymers are not limited thereto. The base polymers may be used alone or in admixture of two or more. In the case of positive resist compositions, it is a common practice to substitute acid labile groups for
 10 hydroxyl groups on phenol, carboxyl groups or fluorinated alkyl alcohols for reducing the rate of dissolution in unexposed regions.

[0033]

The acid labile groups to be introduced into the base
 15 polymers may be selected from a variety of such groups, preferably from acetal groups of 2 to 30 carbon atoms and tertiary alkyl groups of 4 to 30 carbon atoms having the formulae (C1) and (C2), respectively.

[0034]

20 [Formula 16]



[0035]

In formulae (C1) and (C2), R¹ and R² each are hydrogen or a straight, branched or cyclic C₁-C₂₀ alkyl group, which
 25 may contain a hetero atom such as oxygen, sulfur, nitrogen or fluorine, R³, R⁴, R⁵ and R⁶ each are a straight, branched or cyclic C₁-C₂₀ alkyl group, a C₆-C₁₀ aryl group or a C₇-C₁₀ aralkyl group, which may contain a hetero atom such as oxygen, sulfur, nitrogen or fluorine. A pair of R¹ and R², a
 30 pair of R¹ and R³, a pair of R² and R³, a pair of R⁴ and R⁵, a pair of R⁴ and R⁶, or a pair of R⁵ and R⁶, taken together, may form a ring with the carbon atom to which they are attached.

[0036]

Illustrative examples of the acetal group of formula (C1) include, but are not limited to,
methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl,
5 isopropoxymethyl, t-butoxymethyl, 1-methoxyethyl,
1-methoxypropyl, 1-methoxybutyl, 1-ethoxyethyl,
1-ethoxypropyl, 1-ethoxybutyl, 1-propoxyethyl,
1-propoxypropyl, 1-propoxybutyl, 1-cyclopentyloxyethyl,
1-cyclohexyloxyethyl, 2-methoxyisopropyl, 2-ethoxyisopropyl,
10 1-phenoxyethyl, 1-benzyloxyethyl, 1-phenoxypropyl,
1-benzyloxypropyl, 1-adamantyloxyethyl, 1-adamantyloxypropyl,
2-tetrahydrofuryl, 2-tetrahydro-2H-pyranyl,
1-(2-cyclohexanecarbonyloxyethoxy)ethyl,
1-(2-cyclohexanecarbonyloxyethoxy)propyl,
15 1-[2-(1-adamantylcarbonyloxy)ethoxy]ethyl, and
1-[2-(1-adamantylcarbonyloxy)ethoxy]propyl.

[0037]

Illustrative examples of the tertiary alkyl group of formula (C2) include, but are not limited to,
20 t-butyl, t-pentyl, 1-ethyl-1-methylpropyl, 1,1-diethylpropyl,
1,1,2-trimethylpropyl, 1-adamantyl-1-methylethyl,
1-methyl-1-(2-norbornyl)ethyl,
1-methyl-1-(tetrahydrofuran-2-yl)ethyl,
1-methyl-1-(7-oxanorbornan-2-yl)ethyl, 1-methylcyclopentyl,
25 1-ethylcyclopentyl, 1-propylcyclopentyl,
1-cyclopentylcyclopentyl, 1-cyclohexylcyclopentyl,
1-(2-tetrahydrofuryl)cyclopentyl,
1-(7-oxanorbornan-2-yl)cyclopentyl, 1-methylcyclohexyl,
1-ethylcyclohexyl, 1-cyclopentylcyclohexyl,
30 1-cyclohexylcyclohexyl, 2-methyl-2-norbornyl,
2-ethyl-2-norbornyl, 8-methyl-8-tricyclo[5.2.1.0^{2,6}]decyl,
8-ethyl-8-tricyclo[5.2.1.0^{2,6}]decyl,
3-methyl-3-tetracyclo[4.4.0.1^{2,5}.1^{7,10}]dodecyl,
3-ethyl-3-tetracyclo[4.4.0.1^{2,5}.1^{7,10}]dodecyl,
35 2-methyl-2-adamantyl, 2-ethyl-2-adamantyl,
1-methyl-3-oxo-1-cyclohexyl,
1-methyl-1-(tetrahydrofuran-2-yl)ethyl,

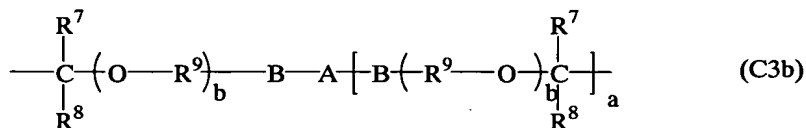
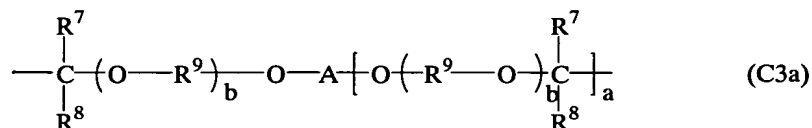
5-hydroxy-2-methyl-2-adamantyl, and
5-hydroxy-2-ethyl-2-adamantyl.

[0038]

In the base resin, at least 1 mol% of hydrogen atoms
of hydroxyl groups may be substituted with acid labile
groups of the following general formula (C3a) or (C3b) for
crosslinkage between molecules or within a molecule.

[0039]

[Formula 17]



[0040]

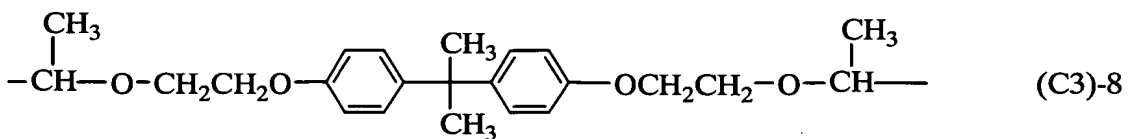
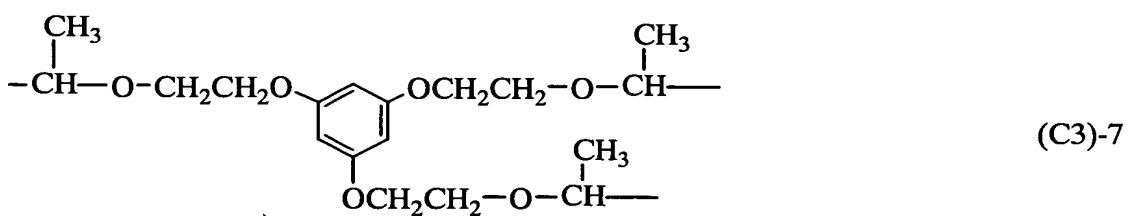
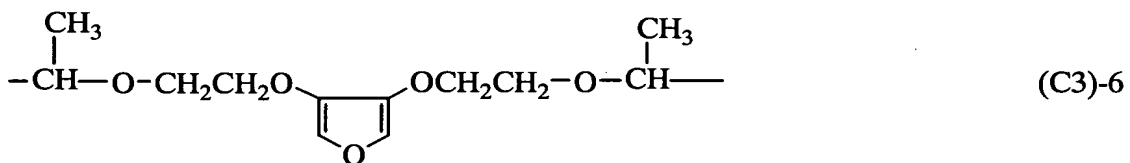
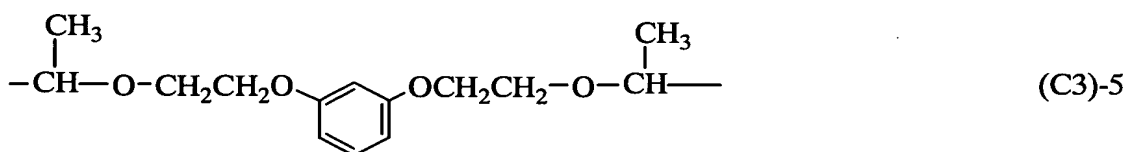
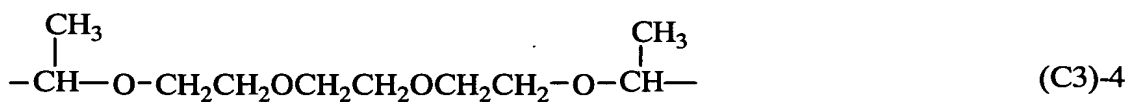
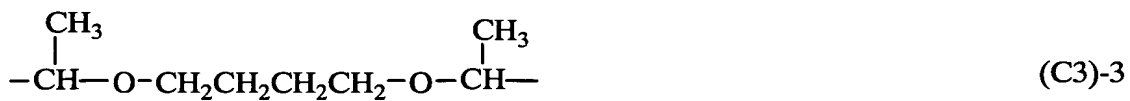
Herein, R^7 and R^8 each are hydrogen or a straight,
branched or cyclic alkyl group of 1 to 8 carbon atoms, or R^7
and R^8 , taken together, may form a ring, with the proviso that
each of R^7 and R^8 is a straight or branched alkylene group of
1 to 8 carbon atoms when they form a ring. R^9 is a straight,
branched or cyclic alkylene group of 1 to 10 carbon atoms.
Letter "a" is an integer of 1 to 7 and "b" is 0 or an integer
of 1 to 10. "A" is a (a+1)-valent aliphatic or alicyclic
saturated hydrocarbon group, aromatic hydrocarbon group or
heterocyclic group of 1 to 50 carbon atoms, which may have an
intervening hetero atom and in which the hydrogen atom
attached to a carbon atom may be partially replaced by a
hydroxyl group, carboxyl group, carbonyl group or fluorine
atom. B is -CO-O-, -NHCO-O- or NHCONH-.

[0041]

Illustrative examples of the crosslinking acetal
linkages represented by formulae (C3a) and (C3b) are given
below as (C3)-1 through (C3)-8, but not limited thereto.

[0042]

[Formula 18]



[0043]

Preferably the base polymer has a weight average molecular weight of 2,000 to 100,000. With Mw below 2,000, film formation and resolution may become poor. With Mw
5 beyond 100,000, resolution may become poor or foreign matter may generate during pattern formation.

[0044]

The photoacid generator (D) contained in the resist composition of the present invention is a compound capable
10 of generating an acid upon exposure to high energy radiation or electron beams.

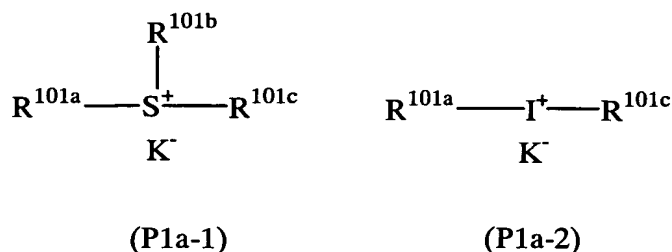
[0045]

The photoacid generator used in the present invention includes the following:

- 15 (i) onium salts of the formula (P1a-1), (P1a-2) or (P1b),
- (ii) diazomethane derivatives of the formula (P2),
- (iii) glyoxime derivatives of the formula (P3),
- (iv) bissulfone derivatives of the formula (P4),
- (v) sulfonic acid esters of N-hydroxyimide compounds of the
20 formula (P5),
- (vi) β -ketosulfonic acid derivatives,
- (vii) disulfone derivatives,
- (viii) nitrobenzylsulfonate derivatives,
- (ix) sulfonate derivatives, and
- 25 (x) oxime sulfonates.

[0046]

[Formula 19]



Herein, R^{101a} , R^{101b} , and R^{101c} independently represent straight,
30 branched or cyclic alkyl, alkenyl or oxoalkyl groups of 1 to 12 carbon atoms, aryl groups of 6 to 20 carbon atoms, or

aralkyl or aryloxoalkyl groups of 7 to 12 carbon atoms, wherein some or all of the hydrogen atoms may be replaced by alkoxy or other groups. Also, R^{101b} and R^{101c} , taken together, may form a ring. R^{101b} and R^{101c} each are alkylene groups of 1 to 6 carbon atoms when they form a ring. K^+ is a non-nucleophilic counter ion.

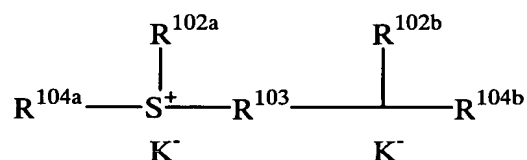
[0047]

R^{101a} , R^{101b} , and R^{101c} may be the same or different and are illustrated below. Exemplary alkyl groups include methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, tert-butyl, pentyl, hexyl, heptyl, octyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclopropylmethyl, 4-methylcyclohexyl, cyclohexylmethyl, norbornyl, and adamantyl. Exemplary alkenyl groups include vinyl, allyl, propenyl, butenyl, hexenyl, and cyclohexenyl. Exemplary oxoalkyl groups include 2-oxocyclopentyl and 2-oxocyclohexyl as well as 2-oxopropyl, 2-cyclopentyl-2-oxoethyl, 2-cyclohexyl-2-oxoethyl, and 2-(4-methylcyclohexyl)-2-oxoethyl. Exemplary aryl groups include phenyl and naphthyl; alkoxyphenyl groups such as p-methoxyphenyl, m-methoxyphenyl, o-methoxyphenyl, ethoxyphenyl, p-tert-butoxyphenyl, and m-tert-butoxyphenyl; alkylphenyl groups such as 2-methylphenyl, 3-methylphenyl, 4-methylphenyl, ethylphenyl, 4-tert-butylphenyl, 4-butylphenyl, and dimethylphenyl; alkylnaphthyl groups such as methylnaphthyl and ethylnaphthyl; alkoxynaphthyl groups such as methoxynaphthyl and ethoxynaphthyl; dialkylnaphthyl groups such as dimethylnaphthyl and diethylnaphthyl; and dialkoxynaphthyl groups such as dimethoxynaphthyl and diethoxynaphthyl. Exemplary aralkyl groups include benzyl, phenylethyl, and phenethyl. Exemplary aryloxoalkyl groups are 2-aryl-2-oxoethyl groups such as 2-phenyl-2-oxoethyl, 2-(1-naphthyl)-2-oxoethyl, and 2-(2-naphthyl)-2-oxoethyl. Examples of the non-nucleophilic counter ion represented by K^+ include halide ions such as chloride and bromide ions, fluoroalkylsulfonate ions such as triflate, 1,1,1-trifluoroethanesulfonate, and nonafluorobutanesulfonate,

arylsulfonate ions such as tosylate, benzenesulfonate, 4-fluorobenzenesulfonate, and 1,2,3,4,5-pentafluorobenzenesulfonate, and alkylsulfonate ions such as mesylate and butanesulfonate.

5 [0048]

[Formula 20]



(P1b)

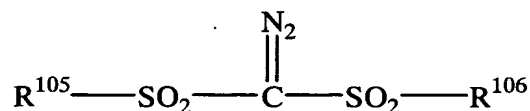
Herein, R^{102a} and R^{102b} independently represent straight, branched or cyclic alkyl groups of 1 to 8 carbon atoms. R^{103} represents a straight, branched or cyclic alkylene groups of 1 to 10 carbon atoms. R^{104a} and R^{104b} independently represent 2-oxoalkyl groups of 3 to 7 carbon atoms. K^- is a non-nucleophilic counter ion.

[0049]

15 Illustrative of the groups represented by R^{102a} and R^{102b} are methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, tert-butyl, pentyl, hexyl, heptyl, octyl, cyclopentyl, cyclohexyl, cyclopropylmethyl, 4-methylcyclohexyl, and cyclohexylmethyl. Illustrative of the groups represented by
20 R^{103} are methylene, ethylene, propylene, butylene, pentylene, hexylene, heptylene, octylene, nonylene, 1,4-cyclohexylene, 1,2-cyclohexylene, 1,3-cyclopentylene, 1,4-cyclooctylene, and 1,4-cyclohexanedimethylene. Illustrative of the groups represented by R^{104a} and R^{104b} are 2-oxopropyl,
25 2-oxocyclopentyl, 2-oxocyclohexyl, and 2-oxocycloheptyl. Illustrative examples of the counter ion represented by K^- are the same as exemplified for formulae (P1a-1) and (P1a-2).

[0050]

[Formula 21]



(P2)

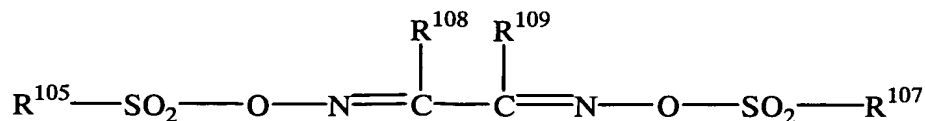
Herein, R^{105} and R^{106} independently represent straight,
 5 branched or cyclic alkyl or halogenated alkyl groups of 1 to
 12 carbon atoms, aryl or halogenated aryl groups of 6 to 20
 carbon atoms, or aralkyl groups of 7 to 12 carbon atoms.

[0051]

Of the groups represented by R^{105} and R^{106} , exemplary
 10 alkyl groups include methyl, ethyl, propyl, isopropyl,
 n-butyl, sec-butyl, tert-butyl, pentyl, hexyl, heptyl,
 octyl, amyl, cyclopentyl, cyclohexyl, cycloheptyl,
 norbornyl, and adamantyl. Exemplary halogenated alkyl
 groups include trifluoromethyl, 1,1,1-trifluoroethyl,
 15 1,1,1-trichloroethyl, and nonafluorobutyl. Exemplary aryl
 groups include phenyl; alkoxyphenyl groups such as
 p-methoxyphenyl, m-methoxyphenyl, o-methoxyphenyl,
 ethoxyphenyl, p-tert-butoxyphenyl, and m-tert-butoxyphenyl;
 and alkylphenyl groups such as 2-methylphenyl,
 20 3-methylphenyl, 4-methylphenyl, ethylphenyl,
 4-tert-butylphenyl, 4-butylphenyl, and dimethylphenyl.
 Exemplary halogenated aryl groups include fluorophenyl,
 chlorophenyl, and 1,2,3,4,5-pentafluorophenyl. Exemplary
 aralkyl groups include benzyl and phenethyl.

[0052]

[Formula 22]



(P3)

Herein, R^{107} , R^{108} , and R^{109} independently represent straight, branched or cyclic alkyl or halogenated alkyl groups of 1 to 12 carbon atoms, aryl or halogenated aryl groups of 6 to 20 carbon atoms, or aralkyl groups of 7 to 12 carbon atoms.

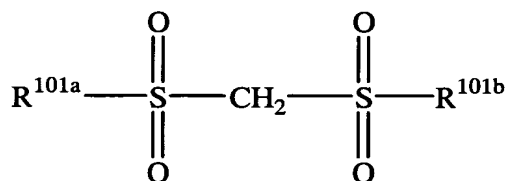
5 Also, R^{108} and R^{109} , taken together, may form a ring. R^{108} and R^{109} each are straight or branched alkylene groups of 1 to 6 carbon atoms when they form a ring.

[0053]

10 Illustrative examples of the alkyl, halogenated alkyl, aryl, halogenated aryl, and aralkyl groups represented by R^{107} , R^{108} , and R^{109} are the same as exemplified for R^{105} and R^{106} . Examples of the alkylene groups represented by R^{108} and R^{109} include methylene, ethylene, propylene, butylene, and hexylene.

15 [0054]

[Formula 23]

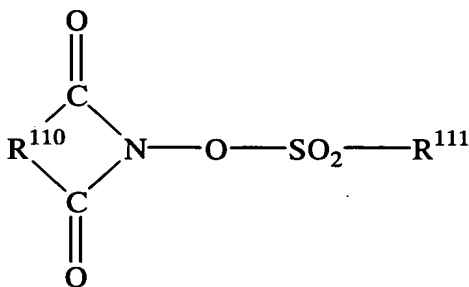


(P4)

Herein, R^{101a} and R^{101b} are as defined above.

[0055]

20 [Formula 24]



(P5)

Herein, R^{110} is an arylene group of 6 to 10 carbon atoms, alkylene group of 1 to 6 carbon atoms, or alkenylene group of 2 to 6 carbon atoms wherein some or all of the hydrogen

atoms may be replaced by straight or branched alkyl or alkoxy groups of 1 to 4 carbon atoms, nitro, acetyl, or phenyl groups. R^{111} is a straight, branched or cyclic alkyl group of 1 to 8 carbon atoms, alkenyl, alkoxyalkyl, phenyl
5 or naphthyl group wherein some or all of the hydrogen atoms may be replaced by alkyl or alkoxy groups of 1 to 4 carbon atoms, phenyl groups (which may have substituted thereon an alkyl or alkoxy of 1 to 4 carbon atoms, nitro, or acetyl group), hetero-aromatic groups of 3 to 5 carbon atoms, or
10 chlorine or fluorine atoms.

[0056]

Of the groups represented by R^{110} , exemplary arylene groups include 1,2-phenylene and 1,8-naphthylene; exemplary alkylene groups include methylene, ethylene, trimethylene,
15 tetramethylene, phenylethylene, and norbornane-2,3-diyl; and exemplary alkenylene groups include 1,2-vinylene, 1-phenyl-1,2-vinylene, and 5-norbornene-2,3-diyl. Of the groups represented by R^{111} , exemplary alkyl groups are as exemplified for R^{101a} to R^{101c} ; exemplary alkenyl groups include
20 vinyl, 1-propenyl, allyl, 1-butenyl, 3-butenyl, isoprenyl, 1-pentenyl, 3-pentenyl, 4-pentenyl, dimethylallyl, 1-hexenyl, 3-hexenyl, 5-hexenyl, 1-heptenyl, 3-heptenyl, 6-heptenyl, and 7-octenyl; and exemplary alkoxyalkyl groups include methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl,
25 pentyloxymethyl, hexyloxymethyl, heptyloxymethyl, methoxyethyl, ethoxyethyl, propoxyethyl, butoxyethyl, pentyloxyethyl, hexyloxyethyl, methoxypropyl, ethoxypropyl, propoxypropyl, butoxypropyl, methoxybutyl, ethoxybutyl, propoxybutyl, methoxypentyl, ethoxypentyl, methoxyhexyl, and
30 methoxyheptyl.

[0057]

Of the substituents on these groups, the alkyl groups of 1 to 4 carbon atoms include methyl, ethyl, propyl, isopropyl, n-butyl, isobutyl and tert-butyl; and the alkoxy
35 groups of 1 to 4 carbon atoms include methoxy, ethoxy, propoxy, isopropoxy, n-butoxy, isobutoxy, and tert-butoxy. The phenyl groups which may have substituted thereon an

alkyl or alkoxy of 1 to 4 carbon atoms, nitro, or acetyl group include phenyl, tolyl, p-tert-butoxyphenyl, p-acetylphenyl and p-nitrophenyl. The hetero-aromatic groups of 3 to 5 carbon atoms include pyridyl and furyl.

5 [0058]

Illustrative examples of the photoacid generator include:
onium salts such as

diphenyliodonium trifluoromethanesulfonate,
(p-tert-butoxyphenyl)phenyliodonium
10 trifluoromethanesulfonate,
diphenyliodonium p-toluenesulfonate,
(p-tert-butoxyphenyl)phenyliodonium p-toluenesulfonate,
triphenylsulfonium trifluoromethanesulfonate,
(p-tert-butoxyphenyl)diphenylsulfonium trifluoromethane-
15 sulfonate,
bis(p-tert-butoxyphenyl)phenylsulfonium trifluoromethane-
sulfonate,
tris(p-tert-butoxyphenyl)sulfonium trifluoromethanesulfonate,
triphenylsulfonium p-toluenesulfonate,
20 (p-tert-butoxyphenyl)diphenylsulfonium p-toluenesulfonate,
bis(p-tert-butoxyphenyl)phenylsulfonium p-toluenesulfonate,
tris(p-tert-butoxyphenyl)sulfonium p-toluenesulfonate,
triphenylsulfonium nonafluorobutanesulfonate,
triphenylsulfonium butanesulfonate,
25 trimethylsulfonium trifluoromethanesulfonate,
trimethylsulfonium p-toluenesulfonate,
cyclohexylmethyl(2-oxocyclohexyl)sulfonium trifluoromethane-
sulfonate,
cyclohexylmethyl(2-oxocyclohexyl)sulfonium p-toluenesulfonate,
30 dimethylphenylsulfonium trifluoromethanesulfonate,
dimethylphenylsulfonium p-toluenesulfonate,
dicyclohexylphenylsulfonium trifluoromethanesulfonate,
dicyclohexylphenylsulfonium p-toluenesulfonate,
trinaphthylsulfonium trifluoromethanesulfonate,
35 cyclohexylmethyl(2-oxocyclohexyl)sulfonium trifluoromethane-
sulfonate,

(2-norbornyl)methyl(2-oxocyclohexyl)sulfonium trifluoro-
methanesulfonate,

ethylenebis[methyl(2-oxocyclopentyl)sulfonium trifluoro-
methanesulfonate], and

5 1,2'-naphthylcarbonylmethyltetrahydrothiophenium triflate;
[0059]

diazomethane derivatives such as

bis(benzenesulfonyl)diazomethane,

bis(p-toluenesulfonyl)diazomethane,

10 bis(xylenesulfonyl)diazomethane,

bis(cyclohexylsulfonyl)diazomethane,

bis(cyclopentylsulfonyl)diazomethane,

bis(n-butylsulfonyl)diazomethane,

bis(isobutylsulfonyl)diazomethane,

15 bis(sec-butylsulfonyl)diazomethane,

bis(n-propylsulfonyl)diazomethane,

bis(isopropylsulfonyl)diazomethane,

bis(tert-butylsulfonyl)diazomethane,

bis(n-amylsulfonyl)diazomethane,

20 bis(isoamylsulfonyl)diazomethane,

bis(sec-amylsulfonyl)diazomethane,

bis(tert-amylsulfonyl)diazomethane,

1-cyclohexylsulfonyl-1-(tert-butylsulfonyl)diazomethane,

1-cyclohexylsulfonyl-1-(tert-amylsulfonyl)diazomethane, and

25 1-tert-amylsulfonyl-1-(tert-butylsulfonyl)diazomethane;

[0060]

glyoxime derivatives such as

bis-O-(p-toluenesulfonyl)- α -dimethylglyoxime,

bis-O-(p-toluenesulfonyl)- α -diphenylglyoxime,

30 bis-O-(p-toluenesulfonyl)- α -dicyclohexylglyoxime,

bis-O-(p-toluenesulfonyl)-2,3-pentanedione-glyoxime,

bis-O-(p-toluenesulfonyl)-2-methyl-3,4-pentanedione-glyoxime,

bis-O-(n-butanedisulfonyl)- α -dimethylglyoxime,

bis-O-(n-butanedisulfonyl)- α -diphenylglyoxime,

35 bis-O-(n-butanedisulfonyl)- α -dicyclohexylglyoxime,

bis-O-(n-butanedisulfonyl)-2,3-pentanedione-glyoxime,

bis-O-(n-butanesulfonyl)-2-methyl-3,4-pentanedione glyoxime,
bis-O-(methanesulfonyl)- α -dimethylglyoxime,
bis-O-(trifluoromethanesulfonyl)- α -dimethylglyoxime,
bis-O-(1,1,1-trifluoroethanesulfonyl)- α -dimethylglyoxime,
5 bis-O-(tert-butanesulfonyl)- α -dimethylglyoxime,
bis-O-(perfluorooctanesulfonyl)- α -dimethylglyoxime,
bis-O-(cyclohexanesulfonyl)- α -dimethylglyoxime,
bis-O-(benzenesulfonyl)- α -dimethylglyoxime,
bis-O-(p-fluorobenzenesulfonyl)- α -dimethylglyoxime,
10 bis-O-(p-tert-butylbenzenesulfonyl)- α -dimethylglyoxime,
bis-O-(xylenesulfonyl)- α -dimethylglyoxime, and
bis-O-(camphorsulfonyl)- α -dimethylglyoxime;

[0061]

bissulfone derivatives such as

15 bisnaphthylsulfonylmethane,
bistrifluoromethylsulfonylmethane,
bismethylsulfonylmethane, bisethylsulfonylmethane,
bispropylsulfonylmethane, bisisopropylsulfonylmethane,
bis-p-toluenesulfonylmethane, and bisbenzenesulfonylmethane;

20 β -ketosulfone derivatives such as

2-cyclohexylcarbonyl-2-(p-toluenesulfonyl)propane and
2-isopropylcarbonyl-2-(p-toluenesulfonyl)propane;

nitrobenzyl sulfonate derivatives such as

2,6-dinitrobenzyl p-toluenesulfonate and
25 2,4-dinitrobenzyl p-toluenesulfonate;

sulfonic acid ester derivatives such as

1,2,3-tris(methanesulfonyloxy)benzene,
1,2,3-tris(trifluoromethanesulfonyloxy)benzene, and
1,2,3-tris(p-toluenesulfonyloxy)benzene; and

30 [0062]

sulfonic acid esters of N-hydroxyimides such as

N-hydroxysuccinimide methanesulfonate,
N-hydroxysuccinimide trifluoromethanesulfonate,
N-hydroxysuccinimide ethanesulfonate,

- N-hydroxysuccinimide 1-propanesulfonate,
N-hydroxysuccinimide 2-propanesulfonate,
N-hydroxysuccinimide 1-pentanesulfonate,
N-hydroxysuccinimide 1-octanesulfonate,
5 N-hydroxysuccinimide p-toluenesulfonate,
N-hydroxysuccinimide p-methoxybenzenesulfonate,
N-hydroxysuccinimide 2-chloroethanesulfonate,
N-hydroxysuccinimide benzenesulfonate,
N-hydroxysuccinimide 2,4,6-trimethylbenzenesulfonate,
10 N-hydroxysuccinimide 1-naphthalenesulfonate,
N-hydroxysuccinimide 2-naphthalenesulfonate,
N-hydroxy-2-phenylsuccinimide methanesulfonate,
N-hydroxymaleimide methanesulfonate,
N-hydroxymaleimide ethanesulfonate,
15 N-hydroxy-2-phenylmaleimide methanesulfonate,
N-hydroxyglutarimide methanesulfonate,
N-hydroxyglutarimide benzenesulfonate,
N-hydroxyphthalimide methanesulfonate,
N-hydroxyphthalimide benzenesulfonate,
20 N-hydroxyphthalimide trifluoromethanesulfonate,
N-hydroxyphthalimide p-toluenesulfonate,
N-hydroxynaphthalimide methanesulfonate,
N-hydroxynaphthalimide benzenesulfonate,
N-hydroxy-5-norbornene-2,3-dicarboxyimide methanesulfonate,
25 N-hydroxy-5-norbornene-2,3-dicarboxyimide trifluoromethane-
sulfonate, and
N-hydroxy-5-norbornene-2,3-dicarboxyimide p-toluenesulfonate.

- Preferred among these photoacid generators are onium
salts such as triphenylsulfonium trifluoromethanesulfonate,
30 (p-tert-butoxyphenyl)diphenylsulfonium trifluoromethane-
sulfonate,
tris(p-tert-butoxyphenyl)sulfonium
trifluoromethanesulfonate,
triphenylsulfonium p-toluenesulfonate,
35 (p-tert-butoxyphenyl)diphenylsulfonium p-toluenesulfonate,
tris(p-tert-butoxyphenyl)sulfonium p-toluenesulfonate,
trinaphthylsulfonium trifluoromethanesulfonate,

cyclohexylmethyl(2-oxocyclohexyl)sulfonium trifluoromethanesulfonate,

(2-norbornyl)methyl(2-oxocyclohexyl)sulfonium trifluoromethanesulfonate, and

5 1,2'-naphthylcarbonylmethyltetrahydrothiophenium triflate; diazomethane derivatives such as

bis(benzenesulfonyl)diazomethane,

bis(p-toluenesulfonyl)diazomethane,

bis(cyclohexylsulfonyl)diazomethane,

10 bis(n-butylsulfonyl)diazomethane,

bis(isobutylsulfonyl)diazomethane,

bis(sec-butylsulfonyl)diazomethane,

bis(n-propylsulfonyl)diazomethane,

bis(isopropylsulfonyl)diazomethane, and

15 bis(tert-butylsulfonyl)diazomethane;

glyoxime derivatives such as

bis-O-(p-toluenesulfonyl)- α -dimethylglyoxime and

bis-O-(n-butanesulfonyl)- α -dimethylglyoxime;

bissulfone derivatives such as bisnaphthylsulfonylmethane;

20 and sulfonic acid esters of N-hydroxyimide compounds such as

N-hydroxysuccinimide methanesulfonate,

N-hydroxysuccinimide trifluoromethanesulfonate,

N-hydroxysuccinimide 1-propanesulfonate,

N-hydroxysuccinimide 2-propanesulfonate,

25 N-hydroxysuccinimide 1-pentanesulfonate,

N-hydroxysuccinimide p-toluenesulfonate,

N-hydroxynaphthalimide methanesulfonate, and

N-hydroxynaphthalimide benzenesulfonate.

[0063]

30 Also included are the oxime sulfonates described in USP 6,004,724, for example,

(5-(4-toluenesulfonyl)oxyimino-5H-thiophen-2-ylidene)-phenylacetonitrile,

(5-(10-camphorsulfonyl)oxyimino-5H-thiophen-2-ylidene)-

35 phenylacetonitrile,

(5-n-octanesulfonyloxyimino-5H-thiophen-2-ylidene)-

phenylacetonitrile,

(5-(4-toluenesulfonyl)oxyimino-5H-thiophen-2-ylidene)(2-methylphenyl)acetonitrile,
(5-(10-camphorsulfonyl)oxyimino-5H-thiophen-2-ylidene)(2-methylphenyl)acetonitrile,
5 (5-n-octanesulfonyloxyimino-5H-thiophen-2-ylidene)(2-methylphenyl)acetonitrile, etc.

[0064]

Also included are the oxime sulfonates described in USP 6,261,738 and JP-A 2000-314956, for example,
10 2,2,2-trifluoro-1-phenyl-ethanone oxime-O-methylsulfonate;
2,2,2-trifluoro-1-phenyl-ethanone oxime-O-(10-camphorylsulfonate);
2,2,2-trifluoro-1-phenyl-ethanone oxime-O-(4-methoxyphenylsulfonate);
15 2,2,2-trifluoro-1-phenyl-ethanone oxime-O-(1-naphthylsulfonate);
2,2,2-trifluoro-1-phenyl-ethanone oxime-O-(2-naphthylsulfonate);
2,2,2-trifluoro-1-phenyl-ethanone oxime-O-(2,4,6-trimethylphenylsulfonate);
20 2,2,2-trifluoro-1-(4-methylphenyl)-ethanone oxime-O-(10-camphorylsulfonate);
2,2,2-trifluoro-1-(4-methylphenyl)-ethanone oxime-O-(methylsulfonate);
25 2,2,2-trifluoro-1-(2-methylphenyl)-ethanone oxime-O-(10-camphorylsulfonate);
2,2,2-trifluoro-1-(2,4-dimethylphenyl)-ethanone oxime-O-(10-camphorylsulfonate);
2,2,2-trifluoro-1-(2,4-dimethylphenyl)-ethanone oxime-O-(1-naphthylsulfonate);
30 2,2,2-trifluoro-1-(2,4-dimethylphenyl)-ethanone oxime-O-(2-naphthylsulfonate);
2,2,2-trifluoro-1-(2,4,6-trimethylphenyl)-ethanone oxime-O-(10-camphorylsulfonate);
35 2,2,2-trifluoro-1-(2,4,6-trimethylphenyl)-ethanone oxime-O-(1-naphthylsulfonate);

- 2,2,2-trifluoro-1-(2,4,6-trimethylphenyl)-ethanone oxime-O-(2-naphthylsulfonate);
- 2,2,2-trifluoro-1-(4-methoxyphenyl)-ethanone oxime-O-methylsulfonate;
- 5 2,2,2-trifluoro-1-(4-methylthiophenyl)-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-1-(3,4-dimethoxyphenyl)-ethanone oxime-O-methylsulfonate;
- 2,2,3,3,4,4,4-heptafluoro-1-phenyl-butanone oxime-O-(10-
- 10 camphorylsulfonate);
- 2,2,2-trifluoro-1-(phenyl)-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-1-(phenyl)-ethanone oxime-O-10-camphorylsulfonate;
- 2,2,2-trifluoro-1-(phenyl)-ethanone oxime-O-(4-methoxy-
- 15 phenyl)sulfonate;
- 2,2,2-trifluoro-1-(phenyl)-ethanone oxime-O-(1-naphthyl)sulfonate;
- 2,2,2-trifluoro-1-(phenyl)-ethanone oxime-O-(2-naphthyl)sulfonate;
- 20 2,2,2-trifluoro-1-(phenyl)-ethanone oxime-O-(2,4,6-trimethylphenyl)sulfonate;
- 2,2,2-trifluoro-1-(4-methylphenyl)-ethanone oxime-O-(10-camphoryl)sulfonate;
- 2,2,2-trifluoro-1-(4-methylphenyl)-ethanone oxime-O-methyl-
- 25 sulfonate;
- 2,2,2-trifluoro-1-(2-methylphenyl)-ethanone oxime-O-(10-camphoryl)sulfonate;
- 2,2,2-trifluoro-1-(2,4-dimethylphenyl)-ethanone oxime-O-(1-naphthyl)sulfonate;
- 30 2,2,2-trifluoro-1-(2,4-dimethylphenyl)-ethanone oxime-O-(2-naphthyl)sulfonate;
- 2,2,2-trifluoro-1-(2,4,6-trimethylphenyl)-ethanone oxime-O-(10-camphoryl)sulfonate;
- 2,2,2-trifluoro-1-(2,4,6-trimethylphenyl)-ethanone oxime-O-
- 35 (1-naphthyl)sulfonate;
- 2,2,2-trifluoro-1-(2,4,6-trimethylphenyl)-ethanone oxime-O-(2-naphthyl)sulfonate;

- 2,2,2-trifluoro-1-(4-methoxyphenyl)-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-1-(4-thiomethylphenyl)-ethanone oxime-O-methylsulfonate;
- 5 2,2,2-trifluoro-1-(3,4-dimethoxyphenyl)-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-1-(4-methoxyphenyl)-ethanone oxime-O-(4-methylphenyl)sulfonate;
- 2,2,2-trifluoro-1-(4-methoxyphenyl)-ethanone oxime-O-(4-methoxyphenyl)sulfonate;
- 10 2,2,2-trifluoro-1-(4-methoxyphenyl)-ethanone oxime-O-(4-dodecylphenyl)sulfonate;
- 2,2,2-trifluoro-1-(4-methoxyphenyl)-ethanone oxime-O-octylsulfonate;
- 15 2,2,2-trifluoro-1-(4-thiomethylphenyl)-ethanone oxime-O-(4-methoxyphenyl)sulfonate;
- 2,2,2-trifluoro-1-(4-thiomethylphenyl)-ethanone oxime-O-(4-dodecylphenyl)sulfonate;
- 2,2,2-trifluoro-1-(4-thiomethylphenyl)-ethanone oxime-O-octylsulfonate;
- 20 2,2,2-trifluoro-1-(4-thiomethylphenyl)-ethanone oxime-O-(2-naphthyl)sulfonate;
- 2,2,2-trifluoro-1-(2-methylphenyl)-ethanone oxime-O-methylsulfonate;
- 25 2,2,2-trifluoro-1-(4-methylphenyl)-ethanone oxime-O-phenylsulfonate;
- 2,2,2-trifluoro-1-(4-chlorophenyl)-ethanone oxime-O-phenylsulfonate;
- 2,2,3,3,4,4,4-heptafluoro-1-(phenyl)-butanone oxime-O-(10-camphoryl)sulfonate;
- 30 2,2,2-trifluoro-1-naphthyl-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-2-naphthyl-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-1-[4-benzylphenyl]-ethanone oxime-O-methylsulfonate;
- 35 2,2,2-trifluoro-1-[4-(phenyl-1,4-dioxa-but-1-yl)phenyl]-ethanone oxime-O-methylsulfonate;
- 2,2,2-trifluoro-1-naphthyl-ethanone oxime-O-propylsulfonate;

2,2,2-trifluoro-2-naphthyl-ethanone oxime-O-propylsulfonate;
2,2,2-trifluoro-1-[4-benzylphenyl]-ethanone oxime-O-propyl-
sulfonate;
2,2,2-trifluoro-1-[4-methylsulfonylphenyl]-ethanone oxime-O-
5 propylsulfonate;
1,3-bis[1-(4-phenoxyphenyl)-2,2,2-trifluoroethanone oxime-O-
sulfonyl]phenyl;
2,2,2-trifluoro-1-[4-methylsulfonyloxyphenyl]-ethanone
oxime-O-propylsulfonate;
10 2,2,2-trifluoro-1-[4-methylcarbonyloxyphenyl]-ethanone
oxime-O-propylsulfonate;
2,2,2-trifluoro-1-[6H,7H-5,8-dioxonaphth-2-yl]-ethanone
oxime-O-propylsulfonate;
2,2,2-trifluoro-1-[4-methoxycarbonylmethoxyphenyl]-ethanone
15 oxime-O-propylsulfonate;
2,2,2-trifluoro-1-[4-(methoxycarbonyl)-(4-amino-1-oxa-pent-
1-yl)-phenyl]-ethanone oxime-O-propylsulfonate;
2,2,2-trifluoro-1-[3,5-dimethyl-4-ethoxyphenyl]-ethanone
oxime-O-propylsulfonate;
20 2,2,2-trifluoro-1-[4-benzyloxyphenyl]-ethanone oxime-O-
propylsulfonate;
2,2,2-trifluoro-1-[2-thiophenyl]-ethanone oxime-O-propyl-
sulfonate; and
2,2,2-trifluoro-1-[1-dioxa-thiophen-2-yl]-ethanone oxime-O-
25 propylsulfonate.

[0065]

Also included are the oxime sulfonates described in
JP-A 9-95479 and JP-A 9-230588 and the references cited
therein, for example,

30 α -(p-toluenesulfonyloxyimino)-phenylacetonitrile,
 α -(p-chlorobenzenesulfonyloxyimino)-phenylacetonitrile,
 α -(4-nitrobenzenesulfonyloxyimino)-phenylacetonitrile,
 α -(4-nitro-2-trifluoromethylbenzenesulfonyloxyimino)-
phenylacetonitrile,
35 α -(benzenesulfonyloxyimino)-4-chlorophenylacetonitrile,
 α -(benzenesulfonyloxyimino)-2,4-dichlorophenylacetonitrile,

- α -(benzenesulfonyloxyimino)-2,6-dichlorophenylacetonitrile,
 α -(benzenesulfonyloxyimino)-4-methoxyphenylacetonitrile,
 α -(2-chlorobenzenesulfonyloxyimino)-4-methoxyphenylaceto-
nitrile,
5 α -(benzenesulfonyloxyimino)-2-thienylacetonitrile,
 α -(4-dodecylbenzenesulfonyloxyimino)-phenylacetonitrile,
 α -[(4-toluenesulfonyloxyimino)-4-methoxyphenyl]acetonitrile,
 α -[(dodecylbenzenesulfonyloxyimino)-4-methoxyphenyl]aceto-
nitrile,
10 α -(tosyloxyimino)-3-thienylacetonitrile,
 α -(methylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
 α -(ethylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
 α -(isopropylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
 α -(n-butylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
15 α -(ethylsulfonyloxyimino)-1-cyclohexenylacetonitrile,
 α -(isopropylsulfonyloxyimino)-1-cyclohexenylacetonitrile, and
 α -(n-butylsulfonyloxyimino)-1-cyclohexenylacetonitrile.

[0066]

- Suitable bisoxime sulfonates include those described
20 in JP-A 9-208554, for example,
bis(α -(4-toluenesulfonyloxy)imino)-p-phenylenediacetonitrile,
bis(α -(benzenesulfonyloxy)imino)-p-phenylenediacetonitrile,
bis(α -(methanesulfonyloxy)imino)-p-phenylenediacetonitrile,
bis(α -(butanesulfonyloxy)imino)-p-phenylenediacetonitrile,
25 bis(α -(10-camphorsulfonyloxy)imino)-p-phenylenediacetonitrile,
bis(α -(4-toluenesulfonyloxy)imino)-p-phenylenediacetonitrile,
bis(α -(trifluoromethanesulfonyloxy)imino)-p-phenylenediaceto-
nitrile,
bis(α -(4-methoxybenzenesulfonyloxy)imino)-p-phenylenediaceto-
30 nitrile,
bis(α -(4-toluenesulfonyloxy)imino)-m-phenylenediacetonitrile,

bis(α -(benzenesulfonyloxy)imino)-m-phenylenediacetonitrile,
bis(α -(methanesulfonyloxy)imino)-m-phenylenediacetonitrile,
bis(α -(butanesulfonyloxy)imino)-m-phenylenediacetonitrile,
bis(α -(10-camphorsulfonyloxy)imino)-m-phenylenediacetonitrile,
5 bis(α -(4-toluenesulfonyloxy)imino)-m-phenylenediacetonitrile,
bis(α -(trifluoromethanesulfonyloxy)imino)-m-phenylenediaceto-
nitrile,
bis(α -(4-methoxybenzenesulfonyloxy)imino)-m-phenylenediaceto-
nitrile, etc.

10 [0067]

These photoacid generators may be used singly or in combinations of two or more thereof. Onium salts are effective for improving rectangularity, while diazomethane derivatives and glyoxime derivatives are effective for
15 reducing standing waves. The combination of an onium salt with a diazomethane or a glyoxime derivative allows for fine adjustment of the profile.

[0068]

The photoacid generator is added in an amount of 0.1
20 to 50 parts, and especially 0.5 to 40 parts by weight, per 100 parts by weight of the base resin. Less than 0.1 part of the photoacid generator may generate a less amount of acid upon exposure, sometimes leading to a poor sensitivity and resolution whereas more than 50 parts of the photoacid
25 generator may adversely affect the transmittance and resolution of resist.

[0069]

To the resist composition, a dissolution inhibitor (E) may be added. The dissolution inhibitor is a compound
30 having on the molecule at least two phenolic hydroxyl groups, in which an average of from 0 to 100 mol% of all the hydrogen atoms on the phenolic hydroxyl groups are replaced with acid labile groups or a compound having on the molecule at least one carboxyl group, in which an average of 50 to
35 100 mol% of all the hydrogen atoms on the carboxyl groups

are replaced with acid labile groups, both the compounds having an average molecular weight within a range of 100 to 1,000, and preferably 150 to 800.

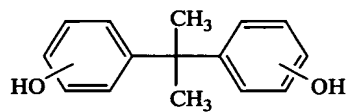
[0070]

5 The degree of substitution of the hydrogen atoms on the phenolic hydroxyl groups with acid labile groups is on average at least 0 mol%, and preferably at least 30 mol%, of all the phenolic hydroxyl groups. The upper limit is 100 mol%, and preferably 80 mol%. The degree of substitution of
10 the hydrogen atoms on the carboxyl groups with acid labile groups is on average at least 50 mol%, and preferably at least 70 mol%, of all the carboxyl groups, with the upper limit being 100 mol%.

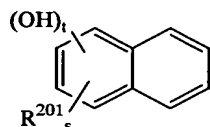
[0071]

15 Preferable examples of such compounds having two or more phenolic hydroxyl groups or compounds having at least one carboxyl group include those of formulas (D1) to (D14) below.

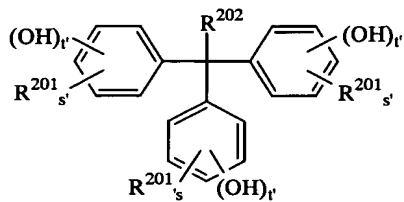
[0072]
[Formula 25]



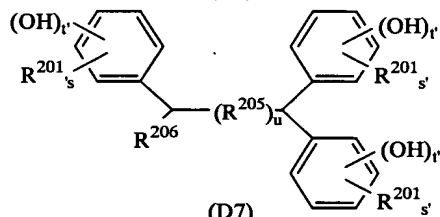
(D1)



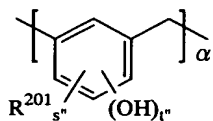
(D3)



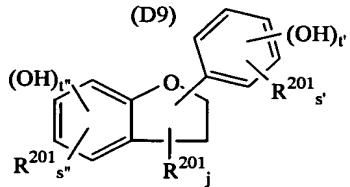
(D5)



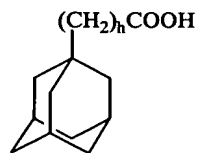
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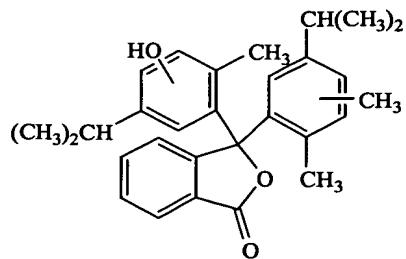
(D9)



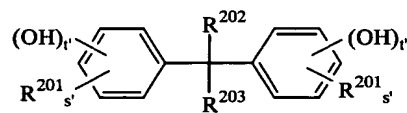
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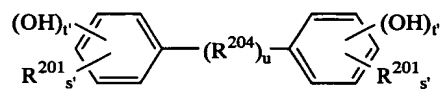
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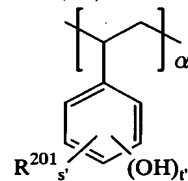
(D2)



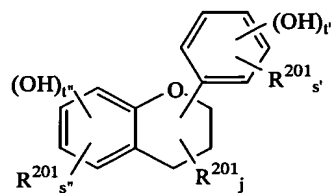
(D4)



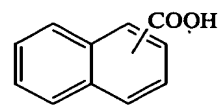
(D6)



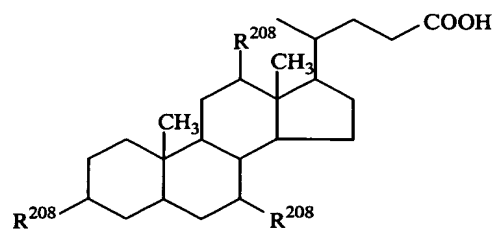
(D8)



(D10)



(D12)



(D14)

[0073]

In these formulas, R^{201} and R^{202} are each hydrogen or a straight or branched alkyl or alkenyl of 1 to 8 carbon atoms; R^{203} is hydrogen, a straight or branched alkyl or alkenyl of 1 to 8 carbon atoms, or $-(R^{207})_h-COOH$; R^{204} is $-(CH_2)_i-$ (where $i = 2$ to 10), an arylene of 6 to 10 carbon atoms, carbonyl, sulfonyl, an oxygen atom, or a sulfur atom; R^{205} is an alkylene of 1 to 10 carbon atoms, an arylene of 6 to 10 carbon atoms, carbonyl, sulfonyl, an oxygen atom, or a sulfur atom; R^{206} is hydrogen, a straight or branched alkyl or alkenyl of 1 to 8 carbon atoms, or a hydroxyl-substituted phenyl or naphthyl; R^{207} is a straight or branched alkylene of 1 to 10 carbon atoms; R^{208} is hydrogen or hydroxyl; the letter j is an integer from 0 to 5; u and h are each 0 or 1; s , t , s' , t' , s'' , and t'' are each numbers which satisfy $s+t = 8$, $s'+t' = 5$, and $s''+t'' = 4$, and are such that each phenyl skeleton has at least one hydroxyl group; and α is a number such that the compounds of formula (D8) or (D9) have a molecular weight of from 100 to 1,000.

[0074]

The above compounds have a weight average molecular weight within a range of 100 to 1,000, and preferably 150 to 800.

[0075]

The dissolution inhibitor may be formulated in an amount of 0 to 50 parts, preferably 5 to 50 parts, and more preferably 10 to 30 parts by weight, per 100 parts by weight of the base resin, and may be used singly or as a mixture of two or more thereof. Too less an amount of the dissolution inhibitor may fail to improve resolution whereas the use of more than 50 parts may lead to slimming of the patterned film, and thus a decline in resolution.

[0076]

Typical crosslinkers (F) are compounds having at least two hydroxymethyl, alkoxymethyl, epoxy or vinyl ether groups within a molecule. Substituted glycoluril derivatives, urea derivatives, and hexa(methoxymethyl)melamine compounds are

suitable as the crosslinker. Examples include N,N,N',N'-tetramethoxymethylurea, hexamethylmelamine, tetraalkoxymethyl-substituted glycoluril compounds such as tetrahydroxymethyl-substituted glycoluril and
5 tetramethoxymethylglycoluril, and condensates of phenolic compounds such as substituted or unsubstituted bis(hydroxymethylphenol) compounds and bisphenol A with epichlorohydrin.

[0077]

10 Especially preferred crosslinkers are 1,3,5,7-tetraalkoxymethylglycolurils such as 1,3,5,7-tetramethoxymethylglycoluril, 1,3,5,7-tetrahydroxymethylglycoluril, 2,6-dihydroxymethyl-p-cresol, 2,6-dihydroxymethylphenol,
15 2,2',6,6'-tetrahydroxymethyl-bisphenol A, 1,4-bis[2-(2-hydroxypropyl)]benzene, N,N,N',N'-tetramethoxymethylurea, and hexamethoxymethylmelamine.

[0078]

20 In the resist composition, an appropriate amount of the crosslinker is, though not limited thereto, 1 to 25 parts, and especially 5 to 20 parts by weight per 100 parts by weight of the base resin in the composition. The crosslinkers may be used alone or in admixture of two or
25 more.

[0079]

In addition to the inventive basic compound, one or more of commonly used basic compounds may be employed in the inventive resist composition. Examples of suitable
30 conventional basic compounds include primary, secondary, and tertiary aliphatic amines, mixed amines, aromatic amines, heterocyclic amines, carboxyl group-bearing nitrogenous compounds, sulfonyl group-bearing nitrogenous compounds, hydroxyl group-bearing nitrogenous compounds, hydroxyphenyl
35 group-bearing nitrogenous compounds, alcoholic nitrogenous compounds, amide derivatives, and imide derivatives.

[0080]

Examples of suitable primary aliphatic amines include ammonia, methylamine, ethylamine, n-propylamine, isopropylamine, n-butylamine, iso-butylamine, sec-butylamine, 5 tert-butylamine, pentylamine, tert-amylamine, cyclopentylamine, hexylamine, cyclohexylamine, heptylamine, octylamine, nonylamine, decylamine, dodecylamine, cetylamine, methylenediamine, ethylenediamine, and tetraethylenepentamine.

10 Examples of suitable secondary aliphatic amines include dimethylamine, diethylamine, di-n-propylamine, di-iso-propylamine, di-n-butylamine, di-iso-butylamine, di-sec-butylamine, dipentylamine, dicyclopentylamine, dihexylamine, dicyclohexylamine, diheptylamine, dioctylamine, 15 dinonylamine, didecylamine, didodecylamine, dicetylamine, N,N-dimethylmethylenediamine, N,N-dimethylethylenediamine, and N,N-dimethyltetraethylenepentamine. Examples of suitable tertiary aliphatic amines include trimethylamine, triethylamine, tri-n-propylamine, tri-iso-propylamine, 20 tri-n-butylamine, tri-iso-butylamine, tri-sec-butylamine, tripentylamine, tricyclopentylamine, trihexylamine, tricyclohexylamine, triheptylamine, trioctylamine, trinonylamine, tridecylamine, tridodecylamine, tricetylamine, N,N,N',N'-tetramethylmethylenediamine, 25 N,N,N',N'-tetramethylethylenediamine, and N,N,N',N'-tetramethyltetraethylenepentamine.

[0081]

Examples of suitable mixed amines include dimethylethylamine, methylethylpropylamine, benzylamine, 30 phenethylamine, and benzyldimethylamine. Examples of suitable aromatic and heterocyclic amines include aniline derivatives (e.g., aniline, N-methylaniline, N-ethylaniline, N-propylaniline, N,N-dimethylaniline, 2-methylaniline, 3-methylaniline, 4-methylaniline, ethylaniline, propylaniline, 35 trimethylaniline, 2-nitroaniline, 3-nitroaniline, 4-nitroaniline, 2,4-dinitroaniline, 2,6-dinitroaniline, 3,5-dinitroaniline, and N,N-dimethyltoluidine),

diphenyl(p-tolyl)amine, methyldiphenylamine, triphenylamine, phenylenediamine, naphthylamine, diaminonaphthalene, pyrrole derivatives (e.g., pyrrole, 2H-pyrrole, 1-methylpyrrole, 2,4-dimethylpyrrole, 2,5-dimethylpyrrole, and N-methylpyrrole), oxazole derivatives (e.g., oxazole and isooxazole), thiazole derivatives (e.g., thiazole and isothiazole), imidazole derivatives (e.g., imidazole, 4-methylimidazole, and 4-methyl-2-phenylimidazole), pyrazole derivatives, furazan derivatives, pyrroline derivatives (e.g., pyrroline and 2-methyl-1-pyrroline), pyrrolidine derivatives (e.g., pyrrolidine, N-methylpyrrolidine, pyrrolidinone, and N-methylpyrrolidone), imidazoline derivatives, imidazolidine derivatives, pyridine derivatives (e.g., pyridine, methylpyridine, ethylpyridine, propylpyridine, butylpyridine, 4-(1-butylpentyl)pyridine, dimethylpyridine, trimethylpyridine, triethylpyridine, phenylpyridine, 3-methyl-2-phenylpyridine, 4-tert-butylpyridine, diphenylpyridine, benzylpyridine, methoxypyridine, butoxypyridine, dimethoxypyridine, 1-methyl-2-pyridone, 4-pyrrolidinopyridine, 1-methyl-4-phenylpyridine, 2-(1-ethylpropyl)pyridine, aminopyridine, and dimethylaminopyridine), pyridazine derivatives, pyrimidine derivatives, pyrazine derivatives, pyrazoline derivatives, pyrazolidine derivatives, piperidine derivatives, piperazine derivatives, morpholine derivatives, indole derivatives, isoindole derivatives, 1H-indazole derivatives, indoline derivatives, quinoline derivatives (e.g., quinoline and 3-quinolinecarbonitrile), isoquinoline derivatives, cinnoline derivatives, quinazoline derivatives, quinoxaline derivatives, phthalazine derivatives, purine derivatives, pteridine derivatives, carbazole derivatives, phenanthridine derivatives, acridine derivatives, phenazine derivatives, 1,10-phenanthroline derivatives, adenine derivatives,

adenosine derivatives, guanine derivatives,
guanosine derivatives, uracil derivatives, and
uridine derivatives.

[0082]

5 Examples of suitable carboxyl group-bearing nitrogenous
compounds include aminobenzoic acid, indolecarboxylic acid,
and amino acid derivatives (e.g. nicotinic acid, alanine,
alginine, aspartic acid, glutamic acid, glycine, histidine,
isoleucine, glycyllleucine, leucine, methionine, phenylalanine,
10 threonine, lysine, 3-aminopyrazine-2-carboxylic acid, and
methoxyalanine). Examples of suitable sulfonyl group-bearing
nitrogenous compounds include 3-pyridinesulfonic acid and
pyridinium p-toluenesulfonate. Examples of suitable hydroxyl
group-bearing nitrogenous compounds, hydroxyphenyl
15 group-bearing nitrogenous compounds, and alcoholic nitrogenous
compounds include 2-hydroxypyridine, aminocresol,
2,4-quinolinediol, 3-indolemethanol hydrate, monoethanolamine,
diethanolamine, triethanolamine, N-ethyldiethanolamine,
N,N-diethylethanolamine, triisopropanolamine,
20 2,2'-iminodiethanol, 2-aminoethanol, 3-amino-1-propanol,
4-amino-1-butanol, 4-(2-hydroxyethyl)morpholine,
2-(2-hydroxyethyl)pyridine, 1-(2-hydroxyethyl)piperazine,
1-[2-(2-hydroxyethoxy)ethyl]piperazine, piperidine ethanol,
1-(2-hydroxyethyl)pyrrolidine,
25 1-(2-hydroxyethyl)-2-pyrrolidinone,
3-piperidino-1,2-propanediol, 3-pyrrolidino-1,2-propanediol,
8-hydroxyjulolidine, 3-quinuclidinol, 3-tropanol,
1-methyl-2-pyrrolidine ethanol, 1-aziridine ethanol,
N-(2-hydroxyethyl)phthalimide, and
30 N-(2-hydroxyethyl)isonicotinamide. Examples of suitable amide
derivatives include formamide, N-methylformamide,
N,N-dimethylformamide, acetamide, N-methylacetamide,
N,N-dimethylacetamide, propionamide, and benzamide. Suitable
imide derivatives include phthalimide, succinimide, and
35 maleimide.

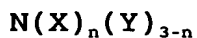
[0083]

In addition, basic compounds of the following general formula (B)-1 may also be included alone or in admixture.

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5 formula (B)-1 may also be included alone or in admixture.

[0084]

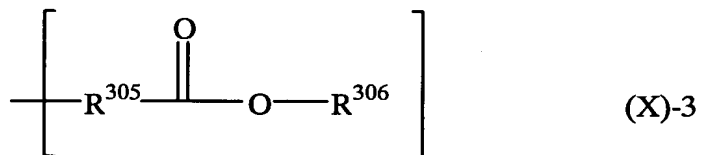
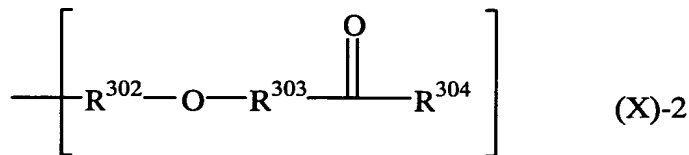
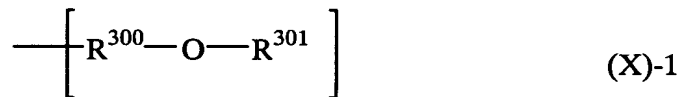


(B)-1

10 In the formula, n is equal to 1, 2 or 3; side chain Y is independently hydrogen or a straight, branched or cyclic alkyl group of 1 to 20 carbon atoms which may contain an ether or hydroxyl group; and side chain X is independently selected from groups of the following general formulas (X)-1
15 to (X)-3, and two or three X's may bond together to form a ring.

[0085]

[Formula 26]



20 [0086]

In the formulas, R^{300} , R^{302} and R^{305} are independently straight or branched alkylene groups of 1 to 4 carbon atoms; R^{301} and R^{304} are independently hydrogen, straight, branched or cyclic alkyl groups of 1 to 20 carbon atoms, which may contain
25 at least one hydroxyl, ether, ester group or lactone ring.

[0087]

R³⁰³ is a single bond or a straight or branched alkylene group of 1 to 4 carbon atoms; and R³⁰⁶ is a straight, branched or cyclic alkyl group of 1 to 20 carbon atoms, which may contain at least one hydroxyl, ether, ester group or lactone ring.

[0088]

Illustrative examples of the basic compounds of formula (B)-1 include tris(2-methoxymethoxyethyl)amine, tris(2-(2-methoxyethoxy)ethyl)amine, tris(2-(2-methoxyethoxymethoxy)ethyl)amine, tris(2-(1-methoxyethoxy)ethyl)amine, tris(2-(1-ethoxyethoxy)ethyl)amine, tris(2-(1-ethoxypropoxy)ethyl)amine, tris[2-{2-(2-hydroxyethoxy)ethoxy}ethyl]amine, 4,7,13,16,21,24-hexaoxa-1,10-diazabicyclo[8.8.8]hexacosane, 4,7,13,18-tetraoxa-1,10-diazabicyclo[8.5.5]eicosane, 1,4,10,13-tetraoxa-7,16-diazabicyclooctadecane, 1-aza-12-crown-4, 1-aza-15-crown-5, 1-aza-18-crown-6, tris(2-formyloxyethyl)amine, tris(2-acetoxyethyl)amine, tris(2-propionyloxyethyl)amine, tris(2-butyryloxyethyl)amine, tris(2-isobutyryloxyethyl)amine, tris(2-valeryloxyethyl)amine, tris(2-pivaloyloxyethyl)amine, N,N-bis(2-acetoxyethyl)-2-(acetoxycetoxy)ethylamine, tris(2-methoxycarbonyloxyethyl)amine, tris(2-tert-butoxycarbonyloxyethyl)amine, tris[2-(2-oxopropoxy)ethyl]amine, tris[2-(methoxycarbonylmethyl)oxyethyl]amine, tris[2-(tert-butoxycarbonylmethyloxy)ethyl]amine, tris[2-(cyclohexyloxy carbonylmethyloxy)ethyl]amine, tris(2-methoxycarbonylethyl)amine, tris(2-ethoxycarbonylethyl)amine, N,N-bis(2-hydroxyethyl)-2-(methoxycarbonyl)ethylamine, N,N-bis(2-acetoxyethyl)-2-(methoxycarbonyl)ethylamine, N,N-bis(2-hydroxyethyl)-2-(ethoxycarbonyl)ethylamine, N,N-bis(2-acetoxyethyl)-2-(ethoxycarbonyl)ethylamine, N,N-bis(2-hydroxyethyl)-2-(2-methoxyethoxycarbonyl)ethylamine,

N,N-bis(2-acetoxyethyl)-2-(2-methoxyethoxycarbonyl)ethylamine,
N,N-bis(2-hydroxyethyl)-2-(2-hydroxyethoxycarbonyl)ethylamine,
N,N-bis(2-acetoxyethyl)-2-(2-acetoxyethoxycarbonyl)ethylamine,
N,N-bis(2-hydroxyethyl)-2-[(methoxycarbonyl)methoxycarbonyl]-
5 ethylamine,
N,N-bis(2-acetoxyethyl)-2-[(methoxycarbonyl)methoxycarbonyl]-
ethylamine,
N,N-bis(2-hydroxyethyl)-2-(2-oxopropoxycarbonyl)ethylamine,
N,N-bis(2-acetoxyethyl)-2-(2-oxopropoxycarbonyl)ethylamine,
10 N,N-bis(2-hydroxyethyl)-2-(tetrahydrofurfuryloxycarbonyl)-
ethylamine,
N,N-bis(2-acetoxyethyl)-2-(tetrahydrofurfuryloxycarbonyl)-
ethylamine,
N,N-bis(2-hydroxyethyl)-2-[(2-oxotetrahydrofuran-3-yl)oxy-
15 carbonyl]ethylamine,
N,N-bis(2-acetoxyethyl)-2-[(2-oxotetrahydrofuran-3-yl)oxy-
carbonyl]ethylamine,
N,N-bis(2-hydroxyethyl)-2-(4-hydroxybutoxycarbonyl)ethylamine,
N,N-bis(2-formyloxyethyl)-2-(4-formyloxybutoxycarbonyl)ethyl-
20 amine,
N,N-bis(2-formyloxyethyl)-2-(2-formyloxyethoxycarbonyl)ethyl-
amine,
N,N-bis(2-methoxyethyl)-2-(methoxycarbonyl)ethylamine,
N-(2-hydroxyethyl)-bis[2-(methoxycarbonyl)ethyl]amine,
25 N-(2-acetoxyethyl)-bis[2-(methoxycarbonyl)ethyl]amine,
N-(2-hydroxyethyl)-bis[2-(ethoxycarbonyl)ethyl]amine,
N-(2-acetoxyethyl)-bis[2-(ethoxycarbonyl)ethyl]amine,
N-(3-hydroxy-1-propyl)-bis[2-(methoxycarbonyl)ethyl]amine,
N-(3-acetoxy-1-propyl)-bis[2-(methoxycarbonyl)ethyl]amine,
30 N-(2-methoxyethyl)-bis[2-(methoxycarbonyl)ethyl]amine,
N-butyl-bis[2-(methoxycarbonyl)ethyl]amine,
N-butyl-bis[2-(2-methoxyethoxycarbonyl)ethyl]amine,
N-methyl-bis(2-acetoxyethyl)amine,
N-ethyl-bis(2-acetoxyethyl)amine,
35 N-methyl-bis(2-pivaloyloxyethyl)amine,
N-ethyl-bis[2-(methoxycarbonyloxy)ethyl]amine,
N-ethyl-bis[2-(tert-butoxycarbonyloxy)ethyl]amine,

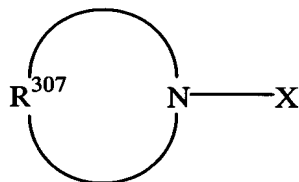
tris(methoxycarbonylmethyl)amine,
tris(ethoxycarbonylmethyl)amine,
N-butyl-bis(methoxycarbonylmethyl)amine,
N-hexyl-bis(methoxycarbonylmethyl)amine, and
5 β -(diethylamino)- δ -valerolactone.

[0089]

Also useful are one or more of cyclic
structure-bearing basic compounds having the following
general formula (B)-2.

10 [0090]

[Formula 27]



(B)-2

Herein X is as defined above, and R³⁰⁷ is a straight or
branched alkylene group of 2 to 20 carbon atoms which may
15 contain one or more carbonyl, ether, ester or sulfide
groups.

[0091]

Illustrative examples of the cyclic structure-bearing
basic compounds having formula (B)-2 include

20 1-[2-(methoxymethoxy)ethyl]pyrrolidine,

1-[2-(methoxymethoxy)ethyl]piperidine,

4-[2-(methoxymethoxy)ethyl]morpholine,

1-[2-[(2-methoxyethoxy)methoxy]ethyl]pyrrolidine,

1-[2-[(2-methoxyethoxy)methoxy]ethyl]piperidine,

25 4-[2-[(2-methoxyethoxy)methoxy]ethyl]morpholine,

2-(1-pyrrolidinyl)ethyl acetate, 2-piperidinoethyl acetate,

2-morpholinoethyl acetate, 2-(1-pyrrolidinyl)ethyl formate,

2-piperidinoethyl propionate,

2-morpholinoethyl acetoxyacetate,

30 2-(1-pyrrolidinyl)ethyl methoxyacetate,

4-[2-(methoxycarbonyloxy)ethyl]morpholine,

1-[2-(t-butoxycarbonyloxy)ethyl]piperidine,

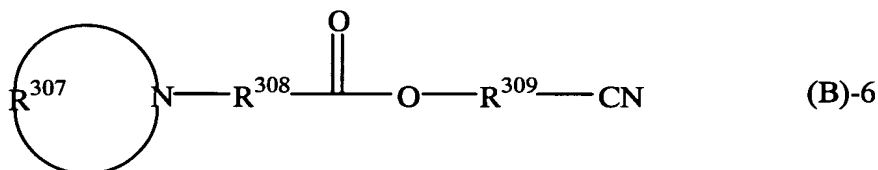
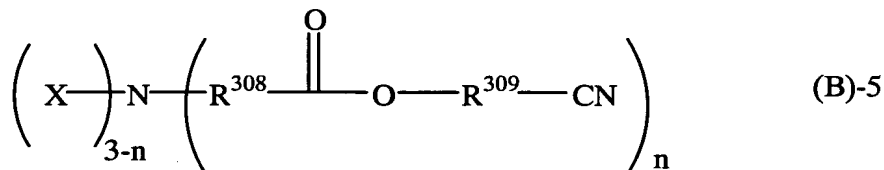
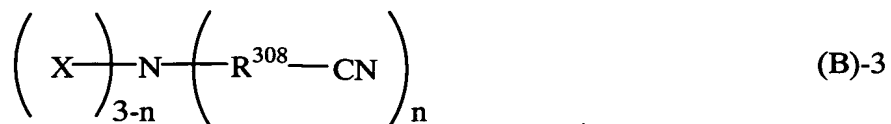
4-[2-(2-methoxyethoxycarbonyloxy)ethyl]morpholine,
methyl 3-(1-pyrrolidinyl)propionate,
methyl 3-piperidinopropionate, methyl 3-morpholinopropionate,
methyl 3-(thiomorpholino)propionate,
5 methyl 2-methyl-3-(1-pyrrolidinyl)propionate,
ethyl 3-morpholinopropionate,
methoxycarbonylmethyl 3-piperidinopropionate,
2-hydroxyethyl 3-(1-pyrrolidinyl)propionate,
2-acetoxyethyl 3-morpholinopropionate,
10 2-oxotetrahydrofuran-3-yl 3-(1-pyrrolidinyl)propionate,
tetrahydrofurfuryl 3-morpholinopropionate,
glycidyl 3-piperidinopropionate,
2-methoxyethyl 3-morpholinopropionate,
2-(2-methoxyethoxy)ethyl 3-(1-pyrrolidinyl)propionate,
15 butyl 3-morpholinopropionate,
cyclohexyl 3-piperidinopropionate,
 α -(1-pyrrolidinyl)methyl- γ -butyrolactone,
 β -piperidino- γ -butyrolactone, β -morpholino- δ -valerolactone,
methyl 1-pyrrolidinylacetate, methyl piperidinoacetate,
20 methyl morpholinoacetate, methyl thiomorpholinoacetate,
ethyl 1-pyrrolidinylacetate, and
2-methoxyethyl morpholinoacetate.

[0092]

Also, one or more of cyano-bearing basic compounds
25 having the following general formulae (B)-3 to (B)-6 may be
blended.

[0093]

[Formula 28]



Herein, X, R³⁰⁷ and n are as defined above, and R³⁰⁸ and R³⁰⁹ are each independently a straight or branched alkylene group of 1 to 4 carbon atoms.

[0094]

Illustrative examples of the cyano-bearing basic compounds include 3-(diethylamino)propiononitrile,
 10 N,N-bis(2-hydroxyethyl)-3-aminopropiononitrile,
 N,N-bis(2-acetoxyethyl)-3-aminopropiononitrile,
 N,N-bis(2-formyloxyethyl)-3-aminopropiononitrile,
 N,N-bis(2-methoxyethyl)-3-aminopropiononitrile,
 N,N-bis[2-(methoxymethoxy)ethyl]-3-aminopropiononitrile,
 15 methyl N-(2-cyanoethyl)-N-(2-methoxyethyl)-3-aminopropionate,
 methyl N-(2-cyanoethyl)-N-(2-hydroxyethyl)-3-aminopropionate,
 methyl N-(2-acetoxyethyl)-N-(2-cyanoethyl)-3-aminopropionate,
 N-(2-cyanoethyl)-N-ethyl-3-aminopropiononitrile,

N-(2-cyanoethyl)-N-(2-hydroxyethyl)-3-aminopropiononitrile,
N-(2-acetoxyethyl)-N-(2-cyanoethyl)-3-aminopropiononitrile,
N-(2-cyanoethyl)-N-(2-formyloxyethyl)-3-aminopropiononitrile,
N-(2-cyanoethyl)-N-(2-methoxyethyl)-3-aminopropiononitrile,
5 N-(2-cyanoethyl)-N-[2-(methoxymethoxy)ethyl]-3-aminopropiono-
nitrile,
N-(2-cyanoethyl)-N-(3-hydroxy-1-propyl)-3-aminopropiono-
nitrile,
N-(3-acetoxy-1-propyl)-N-(2-cyanoethyl)-3-aminopropiono-
10 nitrile,
N-(2-cyanoethyl)-N-(3-formyloxy-1-propyl)-3-aminopropiono-
nitrile,
N-(2-cyanoethyl)-N-tetrahydrofurfuryl-3-aminopropiononitrile,
N,N-bis(2-cyanoethyl)-3-aminopropiononitrile,
15 diethylaminoacetoneitrile,
N,N-bis(2-hydroxyethyl)aminoacetoneitrile,
N,N-bis(2-acetoxyethyl)aminoacetoneitrile,
N,N-bis(2-formyloxyethyl)aminoacetoneitrile,
N,N-bis(2-methoxyethyl)aminoacetoneitrile,
20 N,N-bis[2-(methoxymethoxy)ethyl]aminoacetoneitrile,
methyl N-cyanomethyl-N-(2-methoxyethyl)-3-aminopropionate,
methyl N-cyanomethyl-N-(2-hydroxyethyl)-3-aminopropionate,
methyl N-(2-acetoxyethyl)-N-cyanomethyl-3-aminopropionate,
N-cyanomethyl-N-(2-hydroxyethyl)aminoacetoneitrile,
25 N-(2-acetoxyethyl)-N-(cyanomethyl)aminoacetoneitrile,
N-cyanomethyl-N-(2-formyloxyethyl)aminoacetoneitrile,
N-cyanomethyl-N-(2-methoxyethyl)aminoacetoneitrile,
N-cyanomethyl-N-[2-(methoxymethoxy)ethyl]aminoacetoneitrile,
N-cyanomethyl-N-(3-hydroxy-1-propyl)aminoacetoneitrile,
30 N-(3-acetoxy-1-propyl)-N-(cyanomethyl)aminoacetoneitrile,
N-cyanomethyl-N-(3-formyloxy-1-propyl)aminoacetoneitrile,
N,N-bis(cyanomethyl)aminoacetoneitrile,
1-pyrrolidinepropiononitrile, 1-piperidinepropiononitrile,
4-morpholinepropiononitrile, 1-pyrrolidineacetoneitrile,
35 1-piperidineacetoneitrile, 4-morpholineacetoneitrile,
cyanomethyl 3-diethylaminopropionate,
cyanomethyl N,N-bis(2-hydroxyethyl)-3-aminopropionate,

cyanomethyl N,N-bis(2-acetoxyethyl)-3-aminopropionate,
cyanomethyl N,N-bis(2-formyloxyethyl)-3-aminopropionate,
cyanomethyl N,N-bis(2-methoxyethyl)-3-aminopropionate,
cyanomethyl N,N-bis[2-(methoxymethoxy)ethyl]-3-amino-
5 propionate,
2-cyanoethyl 3-diethylaminopropionate,
2-cyanoethyl N,N-bis(2-hydroxyethyl)-3-aminopropionate,
2-cyanoethyl N,N-bis(2-acetoxyethyl)-3-aminopropionate,
2-cyanoethyl N,N-bis(2-formyloxyethyl)-3-aminopropionate,
10 2-cyanoethyl N,N-bis(2-methoxyethyl)-3-aminopropionate,
2-cyanoethyl N,N-bis[2-(methoxymethoxy)ethyl]-3-amino-
propionate,
cyanomethyl 1-pyrrolidinepropionate,
cyanomethyl 1-piperidinepropionate,
15 cyanomethyl 4-morpholinepropionate,
2-cyanoethyl 1-pyrrolidinepropionate,
2-cyanoethyl 1-piperidinepropionate, and
2-cyanoethyl 4-morpholinepropionate.

[0095]

20 The conventional basic compound is preferably
formulated in an amount of 0 to 2 parts, and especially 0 to
1 part by weight, per 100 parts by weight of the base resin.

[0096]

In addition to the above components, the inventive
25 resist composition may optionally include additives such as
surfactants and acidic compounds.

Patterning with the inventive resist composition may
be carried out by a conventional process. Such a process
typically includes the steps of:

- 30 (1) applying the above-described chemical amplification
resist composition onto a substrate;
(2) heat treating the applied resist, then exposing the
heat-treated resist through a photomask to high-energy
radiation having a wavelength of at most 300 nm,
35 preferably at most 250 nm, or an electron beam; and
(3) heat treating the exposed resist, then developing the
resist with a liquid developer.

[0097]

It is desirable for the basic compound of the invention to be included in an amount of 0.001 to 2 parts by weight, and especially 0.01 to 1 part by weight, per 100 parts by weight of the overall base resin. The use of less than 0.001 part may have no perceivable effect, whereas the use of more than 2 parts may lower the sensitivity of the resist.

[0098]

Preferably, the basic compound of the invention having a benzimidazole skeleton and a polar functional group, represented by formulae (1) to (7), is prepared by a method which is selected optimal for the structure of the compound. Specific, non-limiting, examples are a method using N-alkylation reaction of benzimidazole compounds, and a method using O-acylation or O-alkylation reaction of benzimidazole compounds having a hydroxyalkyl substituent group on N.

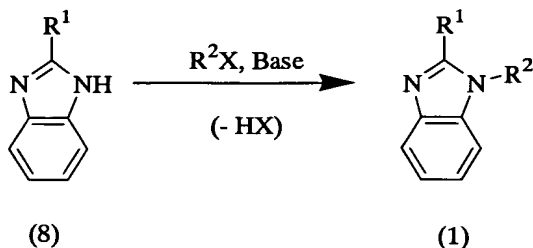
[0099]

The preparation methods are described in detail.

The first method is a preparation method using N-alkylation reaction of benzimidazole compounds. Basically, the method is applicable to the synthesis of all basic compounds having formulae (1) to (7).

[0100]

[Formula 29]



In the above formulae, R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms. R² is a straight, branched or cyclic

alkyl group of 1 to 20 carbon atoms which contains as a polar functional group at least one group selected from among ester, acetal and cyano groups, and optionally at least one group selected from among hydroxyl, carbonyl, ether, sulfide and carbonate groups. X is an eliminatable group such as a halogen atom, p-toluenesulfonyloxy, methanesulfonyloxy, trifluoromethanesulfonyloxy or hydroxyl group.

[0101]

In the above reaction, it is desirable to use the alkylating agent R^2X in an amount of 0.3 to 10 moles, and especially 0.5 to 2 moles, per mole of the benzimidazole compound (8). The reaction may be carried out in a solvent or in the absence of a solvent. Solvents that may be selected in accordance with the reaction conditions and used, either singly or as mixtures thereof, include alcohols such as methanol, ethanol, isopropyl alcohol, t-butyl alcohol and ethylene glycol; hydrocarbons such as hexane, heptane, benzene, toluene and xylene; ethers such as diethyl ether, dibutyl ether, tetrahydrofuran, 1,4-dioxane and diglyme; chlorinated solvents such as methylene chloride, chloroform and 1,2-dichloroethylene; aprotic polar solvents such as N,N-dimethylformamide, N,N-dimethylacetamide, dimethylsulfoxide and N-methylpyrrolidone; carboxylic acids such as formic acid and acetic acid; esters such as ethyl acetate and butyl acetate; ketones such as acetone and 2-butanone; nitriles such as acetonitrile; amines such as pyridine and triethylamine; and water. The reaction temperature may be selected from a range of 0°C to the reflux temperature of the solvent, in accordance with the reaction rate. The base used in the invention may be selected in accordance with the reaction conditions from among amines such as pyridine, triethylamine, diisopropylethylamine, 4-dimethylaminopyridine and imidazole; metal alkoxides such as sodium methoxide, sodium ethoxide and potassium t-butoxide; carbonates such as sodium carbonate, potassium carbonate and cesium carbonate;

hydroxides such as sodium hydroxide, potassium hydroxide and tetramethylammonium hydroxide; metal hydrides such as sodium hydride and potassium hydride; organometallic compounds such as butyllithium and ethyl magnesium bromide; and metal
5 amides such as lithium diisopropylamide. Any one or mixture of these bases may be used. It is desirable to use the base in an amount of from 0.3 to 10 moles, and especially from 1 to 5 moles per mole of the benzimidazole compound (8). An iodide such as sodium iodide, lithium iodide or
10 tetrabutylammonium iodide, or a bromide such as sodium bromide, lithium bromide or tetrabutylammonium bromide, may be added as a catalyst to increase the reaction rate. When a catalyst is added, it is desirable for the amount of such addition to be from 0.001 to 2 moles, and especially from
15 0.005 to 0.5 mole, per mole of the benzimidazole compound (8). To maximize the final yield, it is desirable to monitor the progress of the reaction using gas chromatography (GC) or thin-layer chromatography (TLC) until the reaction is complete. Generally, the reaction time is
20 about 0.5 to 100 hours. The target benzimidazole compound (1) having a polar functional group is obtained by a conventional aqueous work-up from the reaction mixture. If necessary, compound (1) can be purified by an ordinary method such as distillation, chromatography or
25 recrystallization. Alternatively, it may be possible to omit the aqueous work-up, either by using filtration to collect the salt that has formed in the reaction and subjecting the collected salt to purification, or by furnishing the reaction mixture directly to purification.

30 [0102]

Alternatively, the target benzimidazole compounds (1) having polar functional groups can be obtained, depending on the particular structure of the target compounds, by addition of benzimidazole compounds to α,β -unsaturated
35 carbonyl compounds such as acrylic acid esters and acrylonitrile.

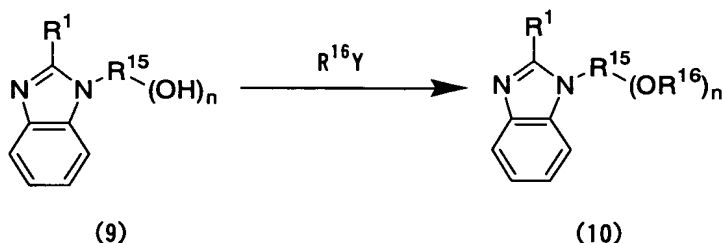
[0103]

The second method is a preparation method using O-acylation or O-alkylation reaction of benzimidazole compounds having a hydroxyalkyl substituent group on N.

5 This method is effective especially for the preparation of basic compounds having formulae (2), (4) and (5).

[0104]

[Formula 30]



10 In the formulae, R¹ is a hydrogen atom, a straight, branched or cyclic alkyl group of 1 to 10 carbon atoms, an aryl group of 6 to 10 carbon atoms, or an aralkyl group of 7 to 10 carbon atoms; R¹⁵ is a (n+1)-valent, straight, branched or cyclic hydrocarbon group of 1 to 10 carbon atoms; R¹⁶ is an
 15 acyl or 1-alkoxyalkyl group; Y is an eliminatable group such as a halogen atom, alkylsulfonyloxy, arylsulfonyloxy, hydroxyl, acyloxy, phenoxy, or alkoxy group, and n is equal to 1 or 2.

[0105]

20 It is noted that the compounds (10) wherein n = 1 and R¹⁶ = acyl correspond to compounds of formula (2), the compounds (10) wherein n = 1 and R¹⁶ = 1-alkoxyalkyl correspond to compounds of formula (5), and the compounds (10) wherein n = 2 correspond to compounds of formula (4).

25 [0106]

In the above reaction, the alkylating or acylating agent R¹⁶Y acts on the N-(hydroxyalkyl)benzimidazole compound (9), which has been prepared by the first method or by addition of benzimidazole compounds to cyclic ethers (e.g.,
 30 ethylene oxide, propylene oxide, glycidol, oxetane) or carbonates (e.g., ethylene carbonate, propylene carbonate),

yielding the target polar functional group-bearing benzimidazole compound (10).

[0107]

When R^{16} is an acyl group, examples of $R^{16}Y$ include, but
5 are not limited to, formic acid, acetic formic anhydride, acetic anhydride, acetic chloride, propionic anhydride, propionic chloride, butyric chloride, isobutyric chloride, valeric chloride, pivalic chloride, methoxyacetic chloride, acetoxyacetic chloride, di-t-butyl pyrocarboxylate,
10 phenyl acetate, p-nitrophenyl acetate, and 2,4,6-trichlorophenyl acetate. When R^{16} is 1-alkoxyalkyl, examples of $R^{16}Y$ include, but are not limited to, methoxymethyl chloride, (2-methoxyethoxy)methyl chloride, (2-methylthioethoxy)methyl chloride,
15 1-chloro-1-ethoxyethane, 1-chloro-1-ethoxypropane, 1-chloro-1-propoxyethane, 2-chlorotetrahydrofuran, and 2-chloro-2H-tetrahydropyran. An appropriate amount of $R^{16}Y$ used per mole of the N-(hydroxyalkyl)benzimidazole compound (9) is from 0.5 to 5.0 moles, especially from 1.0 to 2.5
20 moles in the event $n = 1$, and from 1.0 to 10 moles, especially from 2.0 to 5.0 moles in the event $n = 2$. The reaction may be carried out in a solvent or in the absence of a solvent. Solvents that may be selected in accordance with the reaction conditions and used, either singly or as
25 mixtures thereof, include hydrocarbons such as hexane, heptane, benzene, toluene and xylene; ethers such as diethyl ether, dibutyl ether, tetrahydrofuran, 1,4-dioxane and diglyme; chlorinated solvents such as methylene chloride, chloroform and 1,2-dichloroethylene; aprotic polar solvents
30 such as N,N-dimethylformamide, N,N-dimethylacetamide, dimethylsulfoxide and N-methylpyrrolidone; carboxylic acids such as formic acid and acetic acid; esters such as ethyl acetate and butyl acetate; ketones such as acetone and 2-butanone; nitriles such as acetonitrile; amines such as
35 pyridine and triethylamine; alcohols such as methanol, ethanol, 2-propanol and t-butyl alcohol; and water. In order to promote the reaction, a basic compound may be

added. Examples include, but are not limited to, salts of alkali or alkaline earth metals such as sodium hydroxide, potassium hydroxide, potassium carbonate, sodium carbonate, sodium hydrogen carbonate, sodium hydride, calcium hydride, potassium t-butoxide, and lithium t-butoxide; organometal compounds such as n-butyllithium, lithium diisopropylamide, lithium hexamethyldisilazide, bromomagnesium diisopropylamide; and organic amines such as pyridine, triethylamine, diisopropylethylamine, N,N-dimethylaniline, and 4-dimethylaminopyridine. The basic compound may be used alone or in admixture.

[0108]

An appropriate amount of the basic compound used is from 0.8 to 10 moles, especially from 0.9 to 3.0 moles per mole of $R^{16}Y$. The reaction temperature may be selected from a range of $-70^{\circ}C$ to the reflux temperature of the solvent, preferably $0^{\circ}C$ to $50^{\circ}C$. In the event $R^{16} = \text{acyl}$ and $Y = \text{alkoxy}$, $R^{16}Y$ is a carboxylic acid ester, and the instant reaction is a transesterification reaction. In this event, the above-mentioned basic compound is used as a catalyst in an amount of 0.001 to 5.0 moles, especially 0.005 to 0.5 mole per mole of $R^{16}Y$, and reaction is preferably carried out while distilling off the alcohol ($Y-H$) formed during the reaction. To maximize the final yield, it is desirable to monitor the progress of the reaction using gas chromatography (GC) or thin-layer chromatography (TLC) until the reaction is complete. Generally, the reaction time is about 0.2 to 20 hours. The target polar functional group-bearing benzimidazole compound (10) is obtained by a conventional aqueous work-up from the reaction mixture. If necessary, compound (10) can be purified by an ordinary method such as distillation, chromatography or recrystallization. Alternatively, it may be possible to omit the aqueous work-up, either by using filtration to collect the salt that has formed in the reaction and subjecting the collected salt to purification, or by furnishing the reaction mixture directly to purification.

[0109]

[Effect of the Invention]

Resist compositions prepared using the basic compounds having a benzimidazole skeleton and a polar functional group according to the invention are endowed with an excellent resolution and an excellent focus margin, and are thus useful in microfabrication using electron beams or deep-UV light. The addition of such compounds imparts significant effects in KrF resists, ArF resists, F₂ resists and EB resists. Such resists are highly suitable as micropatterning materials in the manufacture of VLSI chips.

[0110]

[EXAMPLES]

Synthesis Examples, Examples and Comparative Examples are given below by way of illustration, and not by way of limitation.

Basic compounds of the invention were synthesized by the procedure below.

[0111]

[Synthesis Example 1] Synthesis of 2-(1H-benzimidazol-1-yl)ethyl acetate (Amine 2)

A mixture of 118 g of benzimidazole, 48.5 g of ethylene oxide, and 400 g of N,N-dimethylacetamide was heated and stirred in an autoclave at 100°C for 16 hours. The solvent was distilled off in vacuo, yielding crude 2-(1H-benzimidazol-1-yl)ethanol.

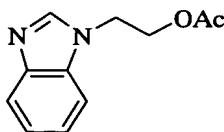
To a mixture of the crude 2-(1H-benzimidazol-1-yl)ethanol and 500 g of pyridine, 122 g of acetic anhydride was added dropwise. In a nitrogen atmosphere, the reaction mixture was stirred at 20°C for 10 hours. The reaction mixture was subjected to conventional aqueous work-up and then purified by vacuum distillation, obtaining 165 g of 2-(1H-benzimidazol-1-yl)ethyl acetate (boiling point 145°C/27 Pa, yield 87%).

IR (thin film): ν = 3089, 3056, 2954, 1741, 1616, 1496, 1459, 1442, 1369, 1332, 1288, 1232, 1207, 1049, 767, 746 cm⁻¹

$^1\text{H-NMR}$ (600 MHz in CDCl_3): δ = 2.00 (3H, s), 4.37-4.43 (4H, m), 7.26-7.33 (2H, m), 7.40 (1H, br. d, $J=7.6$ Hz), 7.81 (1H, br. d, $J=7.6$ Hz), 7.92 (1H, s)

[0112]

5 [Formula 31]



amine 2

[0113]

[Synthesis Example 2] Synthesis of 2-(2-phenyl-1H-benzimidazol-1-yl)ethyl acetate (Amine 4)

10

The procedure of Synthesis Example 1 was repeated aside from using an equimolar amount of 2-phenylbenzimidazole instead of benzimidazole and purifying by column chromatography. There was synthesized

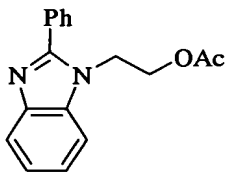
15 2-(2-phenyl-1H-benzimidazol-1-yl)ethyl acetate (yield 80%).

IR (thin film): ν = 2968, 2960, 1729, 1612, 1523, 1473, 1457, 1448, 1436, 1388, 1365, 1355, 1330, 1284, 1272, 1247, 1228, 1166, 1122, 1076, 1047, 1024, 917, 775, 748, 698 cm^{-1}

20 $^1\text{H-NMR}$ (600 MHz in CDCl_3): δ = 1.86 (3H, s), 4.35 (2H, t, $J=5.7$ Hz), 4.51 (2H, t, $J=5.7$ Hz), 7.31-7.34 (2H, m), 7.46 (1H, m), 7.51-7.54 (3H, m), 7.73-7.74 (2H, m), 7.83 (1H, m)

[0114]

25 [Formula 32]



amine 4

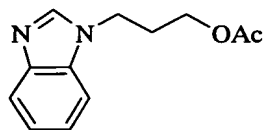
[0115]

[Synthesis Example 3] Synthesis of 3-(1H-benzimidazol-1-yl)propyl acetate (Amine 5)

In a nitrogen atmosphere, a mixture of 118 g of benzimidazole, 181 g of 3-bromopropyl acetate, 111 g of triethylamine, 2 g of sodium iodide, and 500 g of N,N-dimethylformamide was heated and stirred at 80°C for 16 hours. The reaction mixture was subjected to conventional aqueous work-up and then purified by column chromatography, obtaining 3-(1H-benzimidazol-1-yl)propyl acetate (yield 70%).

[0116]

[Formula 33]



amine 5

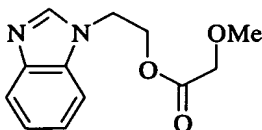
[0117]

[Synthesis Example 4] Synthesis of 2-(1H-benzimidazol-1-yl)ethyl methoxyacetate (Amine 16)

In a nitrogen atmosphere, a mixture of crude 2-(1H-benzimidazol-1-yl)ethanol as prepared in Synthesis Example 1, 156 g of methyl methoxyacetate, 3.0 g of sodium methoxide, and 200 g of diglyme was heated under reflux for 20 hours while distilling off the methanol formed during the reaction. The solvent was distilled off in vacuo. The reaction mixture was subjected to conventional aqueous work-up and then purified by column chromatography, obtaining 2-(1H-benzimidazol-1-yl)ethyl methoxyacetate (yield 65%).

[0118]

[Formula 34]



amine 16

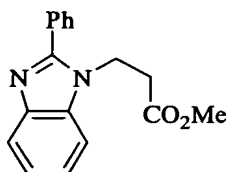
[0119]

[Synthesis Example 5] Synthesis of methyl 3-(2-phenyl-1H-benzimidazol-1-yl)propionate (Amine 26)

A mixture of 194 g of 2-phenylbenzimidazole, 103 g of methyl acrylate and 500 g of methanol was heated and stirred at 60°C for 100 hours. The solvent was distilled off in vacuo, followed by purification by column chromatography. There was obtained methyl 3-(2-phenyl-1H-benzimidazol-1-yl)propionate (yield 60%).

[0120]

[Formula 35]



amine 26

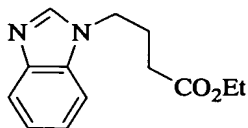
[0121]

[Synthesis Example 6] Synthesis of ethyl 4-(1H-benzimidazol-1-yl)butyrate (Amine 29)

The procedure of Synthesis Example 3 was repeated aside from using an equimolar amount of ethyl 4-bromobutyrate instead of 3-bromopropyl acetate. There was synthesized ethyl 4-(1H-benzimidazol-1-yl)butyrate (yield 82%).

[0122]

[Formula 36]



amine 29

[0123]

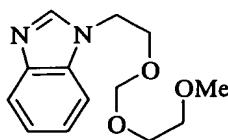
[Synthesis Example 7] Synthesis of 1-[2-[(2-methoxyethoxy)methoxy]ethyl]-1H-benzimidazole (Amine 34)

The procedure of Synthesis Example 3 was repeated aside from using an equimolar amount of

1-bromo-2-[(2-methoxyethoxy)methoxy]ethane instead of 3-bromopropyl acetate. There was synthesized 1-[2-[(2-methoxyethoxy)methoxy]ethyl]-1H-benzimidazole (yield 74%).

5 [0124]

[Formula 37]



amine 34

[0125]

[Synthesis Example 8] Synthesis of 1-[2-(1-ethoxyethoxy)ethyl]-1H-benzimidazole (Amine 38)

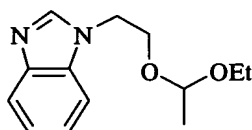
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The procedure of Synthesis Example 3 was repeated aside from using an equimolar amount of 2-bromo-1-(1-ethoxyethoxy)ethane instead of 3-bromopropyl acetate. There was synthesized 1-[2-(1-ethoxyethoxy)ethyl]-1H-benzimidazole (yield 55%).

15

[0126]

[Formula 38]



amine 38

[0127]

[Synthesis Example 9] Synthesis of 1-[(2,2-dimethyl-1,3-dioxolan-4-yl)methyl]-1H-benzimidazole (Amine 54)

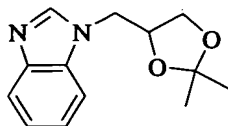
20

The procedure of Synthesis Example 3 was repeated aside from using an equimolar amount of 4-bromomethyl-2,2-dimethyl-1,3-dioxolane instead of 3-bromopropyl acetate. There was synthesized 1-[(2,2-dimethyl-1,3-dioxolan-4-yl)methyl]-1H-benzimidazole (yield 80%).

25

[0128]

[Formula 39]



amine 54

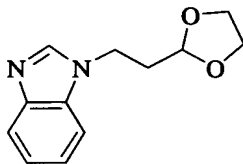
[0129]

5 [Synthesis Example 10] Synthesis of 1-[2-(1,3-dioxolan-2-yl)ethyl]-1H-benzimidazole (Amine 61)

The procedure of Synthesis Example 3 was repeated aside from using an equimolar amount of 2-(2-bromoethyl)-1,3-dioxolane instead of 3-bromopropyl acetate. There was
10 synthesized 1-[2-(1,3-dioxolan-2-yl)ethyl]-1H-benzimidazole (yield 78%).

[0130]

[Formula 40]



amine 61

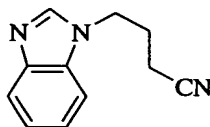
15 [0131]

[Synthesis Example 11] Synthesis of 4-(1H-benzimidazol-1-yl)butyronitrile (Amine 64)

The procedure of Synthesis Example 3 was repeated aside from using an equimolar amount of 4-bromobutyronitrile
20 instead of 3-bromopropyl acetate. There was synthesized 4-(1H-benzimidazol-1-yl)butyronitrile (yield 83%).

[0132]

[Formula 41]



amine 64

[0133]

Resist Evaluation Examples:

In each example, a resist solution was prepared by dissolving a polymer, a photoacid generator, a base, a
5 dissolution inhibitor and a crosslinking agent in a 70:30 by weight solvent mixture of propylene glycol monomethyl ether acetate (PGMEA) and ethyl lactate (EL), then filtering the solution using a Teflon® filter having a pore size of 0.1 μm .

The resulting resist solution was spin-coated onto a
10 silicon wafer substrate on which had been formed a 55 nm thick film of DUV-30 (Nissan Chemical Industries, Ltd.) to hold the reflectance to KrF light (248 nm) to less than 1%, then baked at 100°C for 90 seconds on a hot plate, giving a resist film having a thickness of 550 nm.

15 The resist film was exposed using an excimer laser stepper (NSR-S202A, manufactured by Nikon Corporation; NA = 0.6; $\sigma = 0.75$; 2/3 annular illumination) while varying the exposure dose and focus. Immediately after exposure, the resist was baked at 110°C for 90 seconds, then developed for
20 60 seconds with a 2.38% solution of tetramethylammonium hydroxide in water, giving a resist pattern.

[0134]

The resulting resist patterns were evaluated as described below. The results are shown in Tables 1 and 2.

25 Method of Evaluation:

An optimal exposure dose (Eop) was the exposure which provided a 1:1 resolution of 0.16 μm lines and spaces. A focus margin was determined at the optimal exposure dose (Eop). The focus margin was defined as the absence of
30 pattern film thickness loss and as having a size of not more than 0.16 $\mu\text{m} \pm 10\%$.

[0135]

Table 1

	Polymer (pbw)	Photoacid generator (pbw)	Base (pbw)	Dissolution inhibitor /Crosslinker (pbw)	Sensitivity (mJ/cm ²)	Focus margin (μm)
Example	Polymer5 (100)	PAG3 (2)	Amine2 (0.12)	-	38	1.1
	Polymer5 (100)	PAG3 (2)	Amine4 (0.17)	-	39	1.0
	Polymer5 (100)	PAG3 (2)	Amine5 (0.12)	-	41	0.9
	Polymer5 (100)	PAG3 (2)	Amine16 (0.14)	-	42	1.1
	Polymer5 (100)	PAG3 (2)	Amine26 (0.17)	-	39	1.0
	Polymer5 (100)	PAG3 (2)	Amine29 (0.12)	-	41	1.2
	Polymer5 (100)	PAG3 (2)	Amine34 (0.14)	-	40	0.9
	Polymer5 (100)	PAG3 (2)	Amine38 (0.14)	-	41	1.1
	Polymer5 (100)	PAG3 (2)	Amine54 (0.12)	-	40	1.0
	Polymer5 (100)	PAG3 (2)	Amine61 (0.14)	-	39	1.0
	Polymer5 (100)	PAG3 (2)	Amine64 (0.10)	-	38	1.2
	Polymer1 (100)	PAG5 (2)	Amine2 (0.12)	-	45	0.9
	Polymer2 (100)	PAG5 (2)	Amine2 (0.12)	-	49	0.9
	Polymer3 (100)	PAG5 (2)	Amine2 (0.12)	-	47	1.1
	Polymer3 (100)	PAG4 (2)	Amine2 (0.12)	-	47	1.0
	Polymer4 (100)	PAG2 (2)	Amine2 (0.12)	Crosslinker (15)	31	0.8
	Polymer6 (100)	PAG1 (2)	Amine2 (0.12)	-	45	0.9
	Polymer7 (100)	PAG1 (2)	Amine2 (0.12)	-	47	1.0
	Polymer8 (100)	PAG1 (2)	Amine2 (0.12)	-	42	0.9
	Polymer9 (100)	PAG1 (2)	Amine2 (0.12)	-	39	0.8
	Polymer10 (100)	PAG1 (2)	Amine2 (0.12)	-	46	0.9
	Polymer11 (100)	PAG1 (2)	Amine2 (0.12)	-	42	0.9
	Polymer12 (100)	PAG4 (2)	Amine2 (0.12)	-	46	0.8
	Polymer13 (100)	PAG1 (2)	Amine2 (0.12)	-	45	0.9
	Polymer5 (100)	PAG2 (2)	Amine2 (0.12)	DRI (20)	30	1.0

[0136]

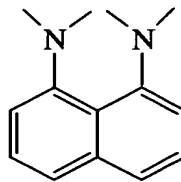
Table 2

	Polymer (pbw)	Photoacid generator (pbw)	Base (pbw)	Dissolution inhibitor /Crosslinker (pbw)	Sensitivity (mJ/cm ²)	Focus margin (μm)
Comparative Example	Polymer5 (100)	PAG2 (2)	-	-	8	0.2
	Polymer5 (100)	PAG2 (2)	1,8- bis(dimethylamino)- naphthalene (0.2)	-	35	0.4
	Polymer5 (100)	PAG2 (2)	DBN (0.1)	-	34	0.4
	Polymer5 (100)	PAG2 (2)	DBU (0.1)	-	32	0.5
	Polymer1 (100)	PAG5 (2)	DBN (0.1)	-	52	0.2
	Polymer2 (100)	PAG5 (2)	DBN (0.1)	-	62	0.5
	Polymer3 (100)	PAG5 (2)	DBN (0.1)	-	51	0.3
	Polymer3 (100)	PAG4 (2)	DBN (0.1)	-	51	0.2
	Polymer4 (100)	PAG2 (2)	DBN (0.1)	Crosslinker1 (15)	33	0.3
	Polymer6 (100)	PAG1 (2)	DBN (0.1)	-	46	0.6
	Polymer7 (100)	PAG1 (2)	DBN (0.1)	-	48	0.6
	Polymer8 (100)	PAG1 (2)	DBN (0.1)	-	42	0.6
	Polymer9 (100)	PAG1 (2)	DBN (0.1)	-	45	0.4
	Polymer10 (100)	PAG1 (2)	DBN (0.1)	-	48	0.3
	Polymer11 (100)	PAG1 (2)	DBN (0.1)	-	42	0.4
	Polymer12 (100)	PAG4 (2)	DBN (0.1)	-	46	0.2
	Polymer13 (100)	PAG1 (2)	DBN (0.1)	-	45	0.3
	Polymer5 (100)	PAG2 (2)	DBN (0.1)	DRI1 (20)	29	0.3

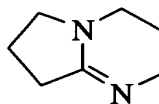
[0137]

[Formula 42]

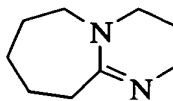
1,8-bis(dimethylamino)naphthalene



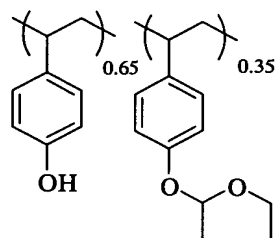
DBN: 1,5-diazabicyclo[4.3.0]-5-nonene



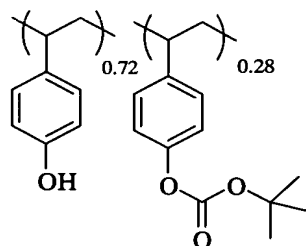
DBU: 1,8-diazabicyclo[5.4.0]-7-undecene



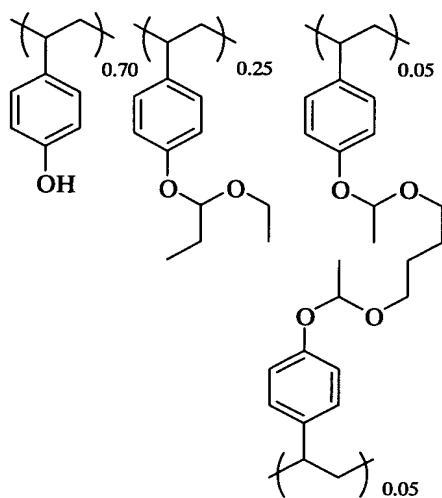
[0138]
[Formula 43]



Polymer1
Mw 10,000
Mw/Mn 1.10

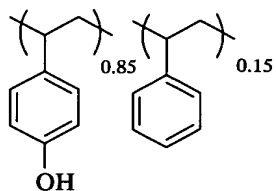


Polymer2
Mw 10,000
Mw/Mn 1.10

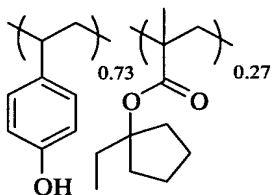


Polymer3
Mw 16,000
Mw/Mn 1.60

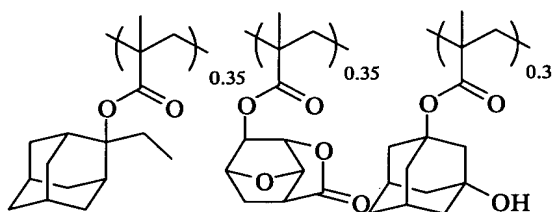
[0139]
[Formula 44]



Polymer4
Mw 10,000
Mw/Mn 1.10

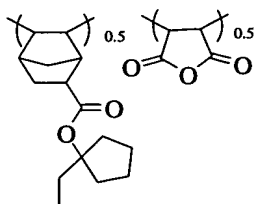


Polymer5
Mw 12,000
Mw/Mn 1.60

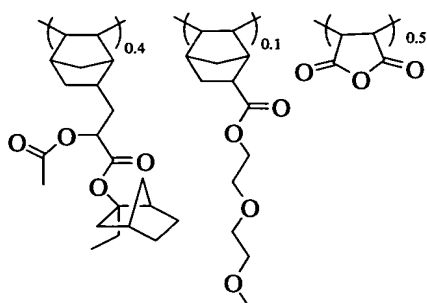


Polymer6
Mw 8,000
Mw/Mn 1.90

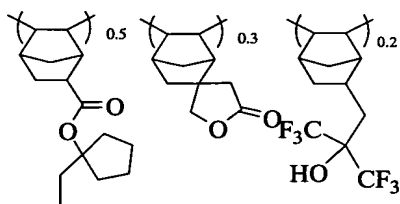
[0140]
[Formula 45]



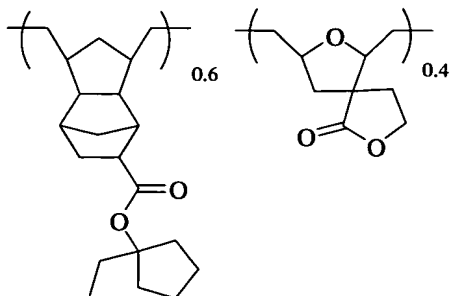
Polymer 7
Mw 10,000
Mw/Mn 1.50



Polymer 8
Mw 11,000
Mw/Mn 1.58

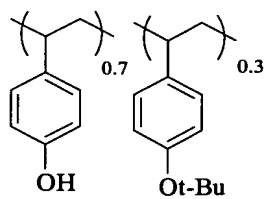


Polymer 9
Mw 8,000
Mw/Mn 2.0

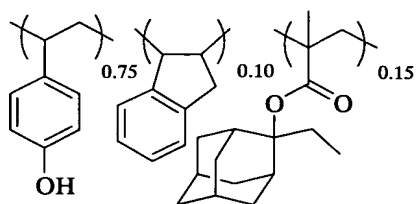


Polymer 10
Mw 13,000
Mw/Mn 1.20

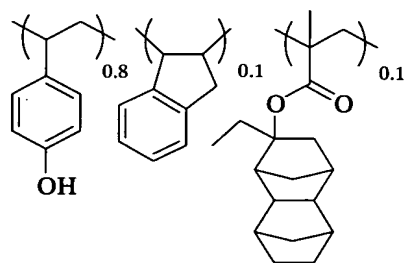
[0141]
[Formula 46]



Polymer11
Mw 8,000
Mw/Mn 1.10

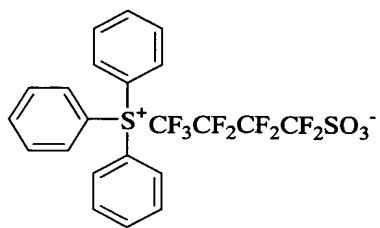


Polymer12
Mw 8,000
Mw/Mn 1.80

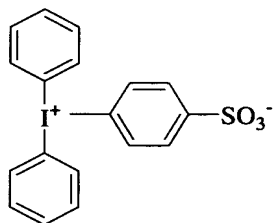


Polymer13
Mw 8,000
Mw/Mn 1.80

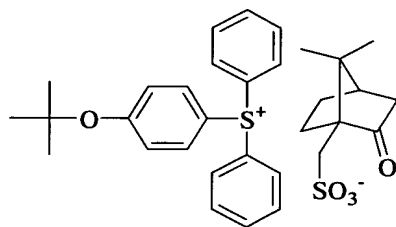
[0142]
[Formula 47]



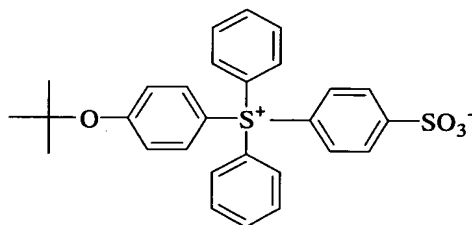
PAG1



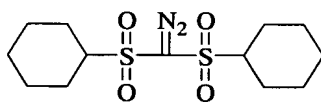
PAG2



PAG3



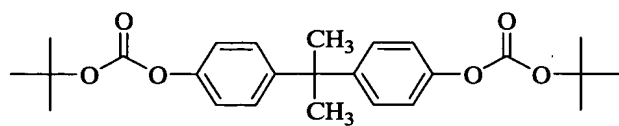
PAG4



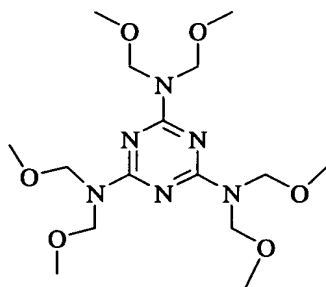
PAG5

[0143]

[Formula 48]



DRI 1



Crosslinker 1

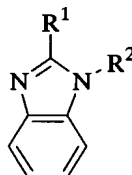
2003-142853

[ABSTRACT]

[Means for Solution]

A resist composition comprising basic compounds having a
5 benzimidazole skeleton and a polar functional group, represented
by the formula (1):

[Formula 1]



(1)

wherein R¹ is a hydrogen atom, alkyl group of 1 to 10 carbon atoms,
10 an aryl group, or an aralkyl group; and R² is a polar functional
group-bearing alkyl group of 1 to 20 carbon atoms wherein said
alkyl group contains as the polar functional group at least one
group selected from among ester, acetal and cyano groups, and
optionally at least one group selected from among hydroxyl,
15 carbonyl, ether, sulfide and carbonate groups.

[Effect]

Resist compositions according to the invention are endowed
with an excellent resolution and an excellent focus margin, and
are thus useful in microfabrication using electron beams or deep-UV
20 light.

[Selected Drawing] none